Audio-tutorial versus traditional instruction in seventh grade mathematics in the Boone Junior High School

Arden Eugene Johnston

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AUDIO-TUTORIAL VERSUS TRADITIONAL INSTRUCTION IN SEVENTH GRADE MATHEMATICS IN THE BOONE JUNIOR HIGH SCHOOL

by

Arden Eugene Johnston

A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of The Requirements for the Degree of DOCTOR OF PHILOSOPHY

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INTRODUCTION

The major procedural function which teachers historically have been providing to facilitate student learning has been instruction—or, more realistically, information giving. In the future, some of this function may be provided by machine technology. The teacher role will be largely that of an instructional leader and will include more important functions such as: (1) prescribing appropriate learning sequences to enable the learner to fully develop his potential; (2) managing a multi-sensory learning environment; and (3) providing the appropriate learning experiences and guiding the learner through the program in such a way as to develop a self-directed, continuously active learner.

Educational programs for the future are anticipated that will involve students at all levels in continuous progress plans or individually planned, competency-based instructional programs not rigidly controlled by specifications. Students should develop a sense of fulfillment which comes only from achievement through self-management and self-discipline.

As a result of the explosion of knowledge, the amount of information that could be communicated has doubled every few years. This development has forced teachers to reexamine the structure of the curriculum in all its facets and to seek new and better ways of disseminating pertinent information to students with varied abilities. The necessity for dealing with more content has also intensified the search for more meaningful and valid research on how people learn and how they should be taught.

Instructional systems which are able to reach more students with less instructional personnel promote the learning of more information with
comprehension and in less time must be developed. Of late, much has been written and said about team teaching, programmed instruction, the Trump Plan, and other developments that exhibit much promise. Implicit in all these plans is the assumption that some part of the responsibility for learning should devolve upon the learner, and that the school is sensitive to his varied needs.

Innovations in the way in which student learning is stimulated, guided, encouraged and evaluated are also greatly needed. The age-old traditions of the teacher-student relationship, the rigid methodology of lecture, recitation, laboratory work and the term paper, and the narrow conception of human learning as specific conditioning need to be modified or superseded by many vigorous efforts to devise a wider range of means of getting effective student learning (66, p. 6).

The presence of great individual differences in aptitude and achievement among students generates important problems of instruction at all levels of the educational system. Learning is an individual process, with a style and a way of working peculiar to each learner (37, p. 9). There is a persistent conviction among educational personnel that the solution to many of the graver problems lies in some kind of plan which will make individualization of instruction possible within the general framework of a mass-instruction organization.

A prodigious amount of literature has been produced since the turn of the century on various types of individual techniques of instruction as well as its importance. It is the belief of Parker (39, p. 138) that the relationship of individualized instruction must be meaningful to the learner as he states:
In education, instruction may be either individualized or grouped. In either event, it should revolve around units of study out of which individual and/or group projects meaningful to the learner are evolved under guidance from the teacher. Skill-using activities will include reading, writing, listening, viewing, discussing, experimenting, and other "doing" activities. The major goal of education is to help the pupil learn how to use his training-acquired skills to generate knowledge and to apply it creatively in decision-making to meet his needs both as an individual and as a member of society.

Considerable work has been done on adapting instruction to individual needs within the classroom as illustrated by programmed instruction, independent study and continuous progress programs. This study deals with another individualizing technique of instruction, audio-tutorial instruction. Audio-tutorial is a multi-faceted, multi-sensory approach with emphasis on student learning rather than on the mechanics of teaching; and is designed to give a student the opportunity to learn at a pace optimal for him.

Statement of the Problem

The problem of this investigation was to determine if audio-tutorial materials could be developed for instruction of seventh grade mathematics students and to evaluate (test) the efficacy of these materials in teaching mathematics to seventh grade students in the Boone Junior High School. More specifically, it was to answer these questions and test the following hypotheses:

Question 1: Can a course in seventh grade mathematics be developed which utilizes the audio-tutorial method of teaching effectively?

Question 2: How do these experiences with this teaching technique affect the students' attitude toward the course?
Question 3: Are students more highly motivated in mathematics when taught by the audio-tutorial technique?

Null hypothesis 1: There will be no significant difference in the post-course mathematics achievement of the audio-tutorial and traditionally-taught students, when initial differences between the two groups have been adjusted with respect to initial knowledge of mathematics (achievement pre-test), intellectual aptitude (group intelligence test), and previous scholastic performance (grade point average).

Null hypothesis 2: There will be no significant difference in the post-course mathematics achievement of male and female students, when initial differences between the two groups have been adjusted with respect to initial knowledge of mathematics (achievement pre-test), intellectual aptitude (group intelligence test), and previous scholastic performance (grade point average).

Null hypothesis 3: There will be no significant difference in the post-course mathematics achievement among the students who have been instructed by a different teacher, when initial differences between the two groups have been adjusted with respect to initial knowledge of mathematics (achievement pre-test), intellectual aptitude (group intelligence test), and previous scholastic performance (grade point average).
Null hypothesis 4: There will be no significant difference in the post-test mathematics achievement between the interaction of teaching technique and sex of students, when initial differences between the two groups have been adjusted with respect to initial knowledge of mathematics (achievement pre-test), intellectual aptitude (group intelligence test), and previous scholastic performance (grade point average).

Null hypothesis 5: There will be no significant difference in the post-test mathematics achievement between the interaction of sex of students and teachers, when initial differences between the two groups have been adjusted with respect to initial knowledge of mathematics (achievement pre-test), intellectual aptitude (group intelligence test), and previous scholastic performance (grade point average).

Purpose of the Study

Students of education and the lay public generally agree that the quality of instruction is the single most important factor in the success of the educational process. The improvement of instruction is then the purpose of this study. The goal of this study is to determine the relative effectiveness of the audio-tutorial teaching procedure versus the traditional method of instruction in seventh grade mathematics. In order to achieve this goal, it was necessary that tutorial materials be
developed so that students could be given instruction by this particular technique.

Instruction must be adapted to the requirements of the content and objectives of the course being taught. Instead of the traditional technique of teaching with the teacher lecturing to the class with only occasional individual or group participation, perpetual content, demonstration, drill, discussion, independent study, and so on, instruction may be more effectively handled in appropriate ways. It was one of the purposes of this study to see if the materials developed were effective in the seventh grade audio-tutorial group.

Definition of Terms

In order to clarify the meanings of the various terms used in this study, the following definitions are made:

Audio-tutorial - Multi-faceted, multi-sensory approach to teaching utilizing audio tapes for instructions in a supervised, self-instructional learning center.

Pre-test - A test (California Achievement Tests, Form X) given to the students in seventh grade mathematics classes before any type of formal instruction in seventh grade mathematics had been given.

Post-test - A test (California Achievement Test, Form W) given to the students in seventh grade mathematics at the completion of one semester of mathematics instruction.

Grade-point average - A cumulative average of course marks, based on a four-point scale, in grades three through six in the following subject matter areas: Health, Language Arts, Mathematics, Reading, Science,
Social Science, and Spelling.

Intellectual aptitude test – A group test (Otis Mental Ability Test, Form Beta E) given to the students in seventh grade mathematics in October, 1968.

Sources of Data

Data pertinent to this study were collected by administering two tests to each student in the control and experimental groups. These tests provide mathematical items which reveal the degree of functional and reasoning ability, thus providing an aid in diagnosing a pupil's specific difficulty. The test further provides ways to reveal whether or not the pupil has sufficient mastery of the fundamental process of addition, subtraction, multiplication, and division (59).

A questionnaire was used to solicit student reactions at the completion of the first week of instruction and at the end of the first nine weeks. Finally, an attitude questionnaire was given to the students to determine their feelings about the instructional methods used in the experiment. This questionnaire was administered at the end of the semester.

Delimitations of the Study

The scope of this investigation was confined to the seventh grade mathematics course in the Boone Junior High School, Boone, Iowa, during the 1968-69 school year. The students involved in the study represented only six sections of the seventh grade. The Boone Junior High School has an ability grouping program for academically talented students and as a
result of testing and teacher evaluation, the top 52 students were not included in the study. The remaining students were assigned to the control and experimental sections by a computer scheduling service used by the school. Consequently, the results of this study refer only to this particular type of student and unit of study.

The entire mathematics course covers one complete year, with the students meeting one hour per day. This study period covers only the first semester of the course.

One of the instructors, Miss Rosemary Hall, developed and assembled the materials used by the students in the study. The textbook, Modern School Mathematics, Grade Seven, Houghton Mifflin Company, used by the control group, was used as a guide in the preparation of the basic audio-tutorial materials. These materials are only as good as the instructor was able to make them.

Three instructors taught a control and an audio-tutorial section of this mathematics course. Each instructor met his control class one hour each day in a classroom adjacent to the laboratory. The audio-tutorial students had access to the audio-tutorial laboratory during this required class time as well as any time the lab was available during the school day. Audio-tutorial instruction has been characterized by supervision over the students as they study. The instructors were not always available when the students came into the audio-tutorial laboratory due to other teaching responsibilities. A high school student served as a monitor over the laboratory, with the function of controlling the materials when the instructors were not available.

The tests (California Achievement Tests, Forms X and W) have a coefficient of reliability of 0.87 for the arithmetic test. The items on
which validity ultimately depends, have been selected to measure many of the universal subject-matter objectives. All of the items included in the present edition have proven to be highly acceptable by modern standards. A critical review of the test items was made by curriculum experts, research specialists, college professors, teachers and state department of education personnel to obtain the best results (59).

The dimensions of this study are restricted to the enrollments of six sections of seventh grade mathematics in the first semester of the 1968-69 school year. There were 139 students enrolled in these classes and included in this study. Seventy-one students were in the audio-tutorial classes and 68 in the control group.

Organization of the Study

The material for this study has been divided into five chapters. The first chapter includes a background of the events, the statement of the problem, definition of terms, sources of data, delimitations of the study, and organization of the study. The second chapter contains a summarization and analysis of related literature and research.

The methodology and procedures for the study are discussed in the third chapter. The fourth chapter is a review of the findings of the data collected during the study. The fifth and final chapter of the study presents a summary of the findings, conclusions, and recommendations for further study.
REVIEW OF THE LITERATURE

Introduction

The preceding chapter stated that the quality of instruction is the single most important factor in the success of the educational process. It has commonly been held that instruction has been to build knowledge, information, attitudes, skills, understandings and behaviors. This chapter cites literature and research pertinent to the problem being investigated, audio-tutorial instruction. In the literature related to this study, three general categories seem relevant: (1) the relationship between the individual and technology or innovation in education, (2) the history of audio-tutorial instruction as developed by S. N. Postlethwait, and (3) a review of research and ongoing audio-tutorial projects. Consequently, such a division has been made in the following review.

Relationship Between the Individual and Technology or Innovation in Education

A prodigious amount of literature has been produced in the last few years on the importance and need for utilization of technology in education. This mass of material presents the need for consideration of the potential use of these technological advances for creating new learning techniques. It is the belief of De Bernardis (13, p. 439) that the use of educational technology is essential for the survival of the educational system and he states:

Modern society depends upon an effective and efficient educational system for survival. Education must make extensive use of the new technology if it is to keep pace with the fast
moving world. Education will have to be concerned with developing human beings who can live effectively in the space age. The teacher will have to move out of the traditional role of dispenser of information and be the professional manager in charge of the learning environment. Through the use of the new educational technology, the learner can be released to move ahead at his own learning pace. He will have access to data and human resources heretofore never available. The teacher will now have the time to develop the dialogue with students. Perhaps with all "hardware" and "software" teachers can use their talents in helping the student to learn to live with himself as well as with other people.

The differences among children require careful consideration if the learning experiences are to be effective and rewarding. It may be possible to provide instruction that is effectively geared to the individual, to his learning capabilities and interests, and to his personal problems. This can be considered by schools if they take advantage of the slowly growing body of competent learning theory, the possible uses of diversified grouping and scheduling, and improved uses of instructional talent through new staffing patterns.

Important problems of instruction at all levels of the educational system have been generated due to the great individual differences in aptitude and achievement among students. Educators' concern with adapting to the needs of the student is a familiar theme which has been repeated over and over again and which provides the justification and basic premise for many current educational innovations and experiments (18, p. 1).

While the problem of individualizing instruction is a formidable one, many recent innovations in instructional materials such as programmed textbooks, cartridge-loading tape recorders and simplified film projectors provide some encouragement for those concerned with individualization. We need to stress in light of innovations that as teaching plans are
constructed and carried out that these be accomplished in light of valid principles and objectives.

There is much concern about new attempts to individualize instruction. Some of this concern is as Glaser (18) has noted, that inertia and practical difficulties have prevented a variety of individualized educational programs from achieving their goal of providing an opportunity for individuals at every level of ability to realize their potentials and to perform at their best. Effective individualized education should provide a system of individualized instruction which nurtures independent learning and a learning environment adapted to the needs of each student. Patterns of individualized instruction have varied from the relatively inflexible program where students are dropped as they reach their presumed levels of achievement, to track plans and individually tailored instructional treatments. Recommendations include—(1) redesigned grade level boundaries and time limits for subject matter coverage, (2) well-defined sequences of behaviorally defined objectives as study guides for individual students, (3) adequate evaluation of a student's progress through a curriculum sequence, (4) instructional materials appropriate for self-directed learning, (5) professional training of school personnel in student evaluation and guidance, and (6) use by teachers of student profiles, automation, and other special techniques to design individualized instructional programs.

Erickson (16, p. 14) postulates that the first and most important professional act of the teacher is to identify valid teaching purposes, that is, the educational objectives that are directly influential and operative as guiding beacons in the day-to-day classroom activities. It
has been emphasized previously that these purposes of the teacher are or should be the understandings, abilities, attitudes, and appreciations operating as determinants of behavior in the lives of the learners.

In light of problems of the learner and the opportunities associated with it, the Learning Research and Development Center at the University of Pittsburgh has chosen for one of its major concentrations of effort to make a study of the problems and possibilities involved in making provisions for individual differences within the context of regular school operation. This project represents an investigation of the problems encountered in the individualization of instruction and involves the development of a program to achieve this goal.

As a result of this project a model for individualization has been developed. Bolvin (9, pp. 14-15) describes the model as he states:

The model for individualization is conceived of as consisting of the following components: (1) sequentially established curricular objectives in each area stated in behavioral terms; (2) a procedure and process for diagnosis of student achievement in terms of objectives of the curriculum and the proficiency level desired for each student and each objective; (3) the necessary materials for individualizing learning to provide a variety of paths for attainment of mastery of any given objective; (4) a system for individually prescribing the learning tasks the student is ready to undertake; (5) the organization and management practices of the total school environment to facilitate individualization; and (6) strategies for continuous evaluation and feedback information for teacher decision making as well as information for continuous evaluation of the curricula for the curriculum developers.

Veatch (64, p. 29) in discussing another aspect of individualization points out that children will study independently more often, with greater concentration, and with greater interest, when that which they study is of their own choice. The child will recognize a need, develop his own means of attacking the problem, and seek the help he needs when he needs
it. Veatch further states that this individual work need not be hurried when the child is the only one doing a certain project, there is no need on the part of the teacher to rush him through the project.

In reviewing the individualized study program in American History at Northport High School, Hunt (23, p. 114) reveals that the students on formal subject matter mastered, as measured by the yearly Regents examination, that the results have not shown any measurable difference, from what could be expected in a more traditional setting. This indicates there has been no sacrifice of factual information under the program. He further reported the two major advantages of the program to be: (1) students get to know their instructors in a different atmosphere, and (2) teachers gain a new respect for the capabilities of students who might before have been regarded as lazy or slow.

To review the literature in this area of independent study would, of course, be a study in itself. Individualization can be of great value if it provides for the needs of the individual in terms of being adequate in our society. On this point Glaser (18, p. 2) states:

Other than the platitude of "catering to the needs of the student," what explicitly can we look to as educational outcomes worth attaining? First, a system of individualized instruction nurtures independent learning and, as a result, has the potential for producing individuals who are self-resourceful and self-appraising learners. Second, instruction which adapts to individual requirements seems impossible to envision without inclusion of the notions of competence, mastery, and the attainment of standards. Unfettered by the practical necessity for group pacing and for adjustments to a teaching strategy adapted to the group average, it appears necessary for each individual to work to attain a standard of performance which permits him to move on in competence and knowledge.

Glaser (18, p. 6) further summarizes the needs of education in the
future as he continues:

It seems possible to develop educational methods that are more sensitive to individual differences than our procedures have been in the past. Educational systems for accomplishing this will no doubt take many forms and have many nuances as they are developed by our educational leaders. In the main, however, it is well to remember that individualization requires the fine honing of instructional procedures so that a student seeks and achieves mastery proceeding along a path, to a large extent, dictated by his own requirements. As a result of a balance between teacher guidance and the student's own self-appraisal, he can follow the path, or blaze the trail, which is neither too difficult nor too easy for him. The teacher in this process will play the significant role of helping the student discover how he learns best; the teacher will need to learn from the learner how to teach; and teach the learner how to learn.

The use of advanced techniques in instruction can free teacher time for more intensive individual work or tutoring and can extend the range of the teacher's influence by enabling a closer relationship between teacher and student. Technology in education may be the factor in the achievement of educational goals in helping to further individualize instruction.

The way is being opened for innovations designed to increase teaching effectiveness while stimulating each student to pursue his education as far as he is able to go. Lanham (28, p. 5) lists four ideas which have liberated and liberalized our attitude toward innovation and experimentation:

... the realization that we have scarcely scratched the surface of man's ability to learn

... the insistence on the importance of individual differences in learning ability and the resulting primacy of individualized instruction

... the quiet but consistent growth of the concept of diagnostic teaching to complement individualized instruction

... the new "value orientation" in education which demands quality as a companion for equality of opportunity.

We assume that science and technology will continue to have a profound
influence on the culture which places demands on education. This requires that some speculation on what kinds of technologies may be developed in coming decades.

Ralph W. Tyler (63, p. 4) in his article, *Innovations in our Schools and Colleges*, identifies new tasks and aims our institutions must be aware of:

A new task faced by our schools and colleges is that attainment of certain new ends or objectives. One of these is to teach students how to learn. With the rapid acquisition of new knowledge, it is no longer possible to give the student in school an adequate command of the facts in each major subject that will serve him throughout the balance of his life. The school can only start him on a lifelong career of continued learning. Hence, an important aim today is to teach students to learn and to develop in them a strong interest in continued study together with the skills required to keep on with their learning after graduation. This objective has not generally been accepted by schools and colleges in the past, although some teachers here and there have given it major attention.

Another new educational aim has arisen from the recent involvement of outstanding scholars in the development of courses and curriculums. In each of the major fields of learning, the scholars are emphasizing the contribution that can be made by learning to use the intellectual apparatus of the field as well as to become familiar with the results of scholarship. In mathematics, for example, the new courses teach the student to think in mathematical terms so that he can deal with the new mathematical ideas and problems, as well as learning the techniques of arithmetic, algebra, geometry, trigonometry and the like. In history, as another example, the new courses teach the student to think in historical terms about the development of cultural, economic and political institutions, as well as learning some of the significant facts and interpretations of previous historical work. This attempt to help the student acquire and use the important intellectual tools is a new educational aim that has not been widely attempted in the past. It is another illustration of the fact that one of the new tasks of our schools and colleges is to aim at certain new objectives.

The imperative need for educational innovations at this time arises not only from the importance of doing the traditional educational jobs more effectively and efficiently with a greatly increased population, but also because we face new tasks for
which we have no extended experience and no adequately tested
document to guide us.

Another area in which innovations are emerging is in the use
of modern technology for educational purposes. This quickly
brings to mind educational television, motion pictures, tape
recordings, teaching machines, programmed material and
computer-assisted instruction. There is high current interest
in these developments. At the present time, however, the
yield from the innovative efforts has been small. Too many
of the projects undertaken have been guided by those whose
training and competence are in the technology, and they have not
been wholly familiar with the educational tasks, the aims
sought, the conditions of learning to be maintained and the
like. However, today some experiments have been started by
persons who have the educational competence as well as having
knowledge of the technology being used. We need many more
efforts of this sort in order to gain the possible values of
technology for the benefit of education.

One caution presented by Adelson (1) concerning innovation is that
the process of scrutiny needs as much attention as the process of innova-
tion. Improperly devised innovations such as those based on too narrow a
view of the future, could, if adopted without adequate evaluation, seri-
ously damage the lives of individuals subjected to them.

In the past we developed in this country a wide range of what would
now be called conventional audio-visual devices. Even these have not
reached a saturation level of use. Within the past 15 years many newer
devices have been introduced: television, language labs, programmed
learning, 8mm sound projectors, multi-media presentations for large groups,
and so on. We are faced with putting together the technology of mass
instruction and even the new technology of individual instruction into
coherent instructional systems.

Now that media devices are beginning to be used on a wider scale, we
need to develop patterns of organization and media management that remove
the confusion and utilize the potential of this development that exists.
This new thinking calls for change in facilities and furniture design, about library functions, and about curriculum. The whole purpose of the greater use of technology for learning is to bring about in each learner some kind of change in behavior which we who are involved in education want to see brought about.

It is necessary that we analyze the processes of learning that accrue as a consequence of the use of the various media and technological devices. Many efforts are being directed toward a study of media utilization in the classroom and its effectiveness for the learner.

One such study began in 1952 (26), when the Benedictine Sisters began experimenting with tape teaching in Covington, Louisiana. After five years of experimentation, the nuns were so pleased with the developments and progress of students that the entire school was equipped for electronic teaching.

Each summer the Sisters conduct workshops to train teachers in the technique of tape teaching. The teachers from the Norwalk School System attended the workshops in 1961. A pattern of teaching with magnetic tape that involved the use of student earphones, student activity sheets, and a carefully worked-out set of learning objectives were developed.

Norwalk and many other communities have moved ahead to make tape teaching part of the regular instructional program. The schools have found many advantages for the teacher. Lalime (26, p. 454) lists the advantages of the system as he states:

Taped lessons offer many advantages to the teacher. They serve to make more economical use of teacher time and provide instructional materials which can be developed for varying levels of pupils' achievement. Tapes yield a flexibility in
grouping and subject matter which fosters individualized instruction. Prerecorded instructional tape lessons can be used for remedial purposes, to increase skills, for enrichment, follow-up activities, practice, reinforcement of known skills, and review. Taped lessons can be thought-provoking and exciting to children as they work independently, making it possible for the teacher to concentrate on the instructional needs of the children in another group without interruption. The impact of the teacher's personality and voice is reflected through this medium. Materials can be developed to meet the student's educational requirements. The tape lesson provides greater concentration because earphones eliminate almost all extraneous sounds.

Commercially prepared records can also be linked to the tape tables and earphone system. Many teachers believe that the earphones add a new dimension to listening. Teachers have indicated that recorded programs played to the entire class were not effective, but when used with earphones the recorded programs were a "great success."

The values of using recorded lessons for the improvement of instruction seem to be limitless. When properly used, the technique of using recorded lessons on tape is applicable to almost any educational situation. In a sense, it can allow the teacher in the self-contained classroom to be in two places at the same time. It can be a great help in providing for the learning needs of an individual within a group and for providing greater latitude in grouping than is possible within the limits of the traditional grouping method. Tapes can be prepared to suit the needs of one, two, twenty, or one hundred students. It provides the teacher the opportunity to individualize instruction on a larger scale, improve instruction, and bring to larger groups of students many activities they might otherwise have missed.

Rowlett (50) conducted a study in 1966 to determine the effectiveness of direct-detailed and directed-discovery methods of presenting tape-recorded instruction related to developing an understanding of an industrial arts technique. The students were exposed to instruction by a step-by-step procedure (direct-detailed) on tape as compared to the tape with only a brief introduction (directed-discovery) and were left with a great deal of freedom in developing their own understanding of the technique being taught.
Rowlett found that both methods were equally effective in regard to the initial learning. The study also indicated that both methods of organizing taped instruction were productive of learning that was immediately usable and persisted for at least six weeks.

In 1967, Bennett (8) conducted some variations of tape teaching in Latin when he could not utilize the language laboratory with 100 percent efficiency. He taped extra series of the basic constructions and used them several times a week in and after class study. He also included a tape of quiz sentences for the slow learners. In discussing his findings, he reported that the method seemed to be teaching more material than the teacher could otherwise have given, that the voice on the tape was psychological in keeping the students working and it gave the teacher time to isolate problems and check the students' levels of achievement.

Nunn (38, p. 1336) in writing of criteria necessary for the development of putting successful tutorials on tape stresses the one important element which tends to be lacking — student participation.

In 1968, Douglas (14) reported on Project Springboard which began during the 1966-67 school year. It was developed by the Oregon State Department of Education, selected local school districts, and a group of major audio-visual companies. It is the first working professional partnership in the nation involving three such groups in a cooperative venture to move a tested new idea into practice through a widespread, coordinated demonstration in a single state. The project was to determine what can happen when teachers and students have immediate access to good learning materials and supporting audio-visual equipment.
Each classroom in the project schools has been supplied with basic audio-visual equipment as well as each building assembling a comprehensive collection of AV materials. In-service sessions have given the teachers new skills in using the materials effectively. As teachers move into broader and more intensive use of media in new and creative combinations, success with learners continues to fuel the fires of motivation. He summarizes this project by stating:

Classroom availability has encouraged highly creative uses of media in Springboard schools. Rather than everyone in a class having to participate in the same activity at the same time, several learning stations can be underway simultaneously, using a variety of learning experiences without undue dependence on print alone; teachers are able to realize the potentialities of varying combinations of groups and media methods, and then can take a giant step toward individualizing instruction by varying the mix of media to more closely match the needs of small groups and single pupils.

In the past the tradition of instruction is that the classroom teacher is the sole arbiter of instruction and that he has regarded audio-visual materials as being "aids to instruction." William Trow (62, p. 180) in his book, Teacher and Technology, New Design for Learning, expresses his concern for the new technology as he states:

The new media will not be particularly effective so long as they remain mere aids or adjuncts, an intrusion, a fifth wheel to the educational conveyance. The new parts need to be integrated into a man-machine system, and this requires clear-cut readjustments in organization and procedure. The required changes may take a little time but they are well within the range of feasibility. The educational technologist envisions not machine-produced robots, but a smoothly functioning system in which the several processes it employs are all to turn out its product -- and that product is educated people. It is not realistic to expect that the product will be perfect. But the schools of tomorrow can be far better places to live and to learn than the schools of today.
The problem in education defined in the simplest terms is "learning must be done by the learner." While it is highly desirable to know more about the learning process, it is not necessary to delay the utilization of technological improvements until the information is available. We are already well aware of certain situations and activities which contribute to learning. It is logical then that we identify these conditions and structure an educational program to permit students to exploit these learning principles (44, p. 54).

It is necessary that both the teacher and the student be concerned with the kinds of activities which contribute to the learning activities. In light of this philosophy, S. N. Postlethwait identified the activities and situations which he believes a course must contain in order for the learning to be done by the learner.

Some of the learning activities as Postlethwait (2, pp. 3-4) sees them are:

1. **Repetition**—There is little question but that the nature of many objectives require repetition for their achievement. However, repetition ought to be engaged in an intelligent fashion and adapted to the individual needs of a particular student.

2. **Concentration**—Most classrooms are not organized to permit students to concentrate during their study. Students are distracting to one another and other disassociated events which may be occurring tend to distract the student's attention from the subject at hand.

3. **Association**—Diagrams, charts, models, photographs, and other such devices should be a "means to the end" so that students' attention is directed to the subject itself. The system should provide an opportunity for the student
to have an object available at the time he reads about it, etc.

(4) **Appropriate sized units of subject matter**—People vary considerably in the amount of subject matter that can be grasped in a given amount of time. Programmers have demonstrated that most people can learn almost anything if it is broken into small enough units and the student can take time to become informed about each unit before proceeding to the next. Any program of study therefore should provide each student an opportunity to adjust the size of the unit to his own ability to assimilate the information, so that those who can absorb large quantities of information may do so in an unrestricted fashion, whereas others who must proceed more slowly are permitted to do so.

(5) **Adapt the nature of the communication vehicle to the nature of the objective**—It is logical that no simple vehicle such as lecturing or a textbook can achieve the full spectrum of objectives for a complex subject. The student's experiences should not be confined to any particular vehicle as film, audio tape, textbook, or a lecture. A properly structured course, therefore, would carefully define objectives and not try to mold objectives to fit a favorite medium (lecture, for example) but instead would use the medium best adapted to the nature of the objective.

(6) **The use of multi-media**—Individuals differ in their responsiveness to different kinds of communication devices. Some people learn well through reading, some can learn best by auditory communication, and others learn best by literally handling specimens and performing experiments.

(7) **Finally, and most important, the integration of learning activities and situations**—It stands to reason that if learning events are to be complementary and to have some relationship, they should be brought into close proximity and properly sequenced.

The term "integrated experience" is derived from the fact that a wide variety of teaching learning experiences are integrated, with provision for individual student differences, and each experience planned to present efficiently some important aspect of the subject. Emphasis on student learning rather than on the mechanisms of teaching is the basis of the integrated experience approach. It involves the teacher identifying as
clearly as possible those responses, attitudes, concepts, ide:-s, and manipulating skills to be achieved by the student and then designing a multi-faceted multi-sensory approach which will enable the student to direct his own activity to attain these objectives. The program of learning is organized in such a way that students can proceed at their own pace, filling gaps in their background information and omitting the portions of the program which they have covered at some previous time. It makes use of every educational device available and attempts to align the exposure to these learning experiences in a sequence which will be most effective and efficient. The kind, number, and nature of the devices involved will be dependent on the nature of the subject under consideration (47).

Dr. S. N. Postlethwait, a biology professor at Purdue University, has been a leader in the development of the audio-tutorial approach. This system of instruction was developed to make an adjustment for the diversity of backgrounds among students (33). This approach retains important attributes such as personal contact between student and teacher in the face of rising class enrollments while supplementing these with the use of modern communication devices to provide better learning opportunities.

The inception of the audio-tutorial approach as currently used at Purdue University was in 1961. In order to provide for individual differences within the class, Postlethwait began by putting supplemental lectures on tape for use by the slower students at their convenience. The system developed from a series of taped lectures, to a set of integrated experiences, including lectures, demonstrations, set-ups, doing experiments, watching movies, and other appropriate activities helpful in
understanding the subject matter. By the end of the semester, a weekly learning kit was prepared and the students were able to complete a week's work without attending any of the formal sessions of the course. Response by the students was so favorable to this supplemental material, that an experimental section of 36 students were offered all instruction programmed by audio tape. These students met once each week with the instructor for a discussion session and to take quizzes. The same examinations were administered to the experimental group as the students in the conventionally-taught classes. An evaluation of the students in both groups at the end of the semester showed no difference in their achievement. The 36 experimental students were interviewed as to how to develop a study program in plant science which would have flexibility and continue to be a quality program. As a result of these discussions, the freshman botany course at Purdue has been restructured utilizing the audio-tutorial approach (47, pp. 7-8).

In developing the new approach, the teaching assistants, students, H. Murray, J. Novak and the author combined their efforts to examine all course activities in terms of contributions to the learning process and to restructure the course accordingly. The basic guidelines were: (1) learning requires involvement of the learner at a pace and time optimal for him, and (2) opportunities should be provided for repetition, concentration, multi-sensory exposure to subject matter, an appropriate sequencing of learning events, and interaction with fellow students and instructors. Following these guidelines required provision for flexible scheduling of a great variety of activities, with emphasis on the
students' initiative (33, p. 315).

Postlethwait and his colleagues completely restructured the botany course along lines of independent study exercises, including laboratory experience which the student could gain at his own pace and repeat as necessary to achieve the necessary learning results. In addition to this independent study, one hour a week was set up for a general-assembly session and one hour a week for small-group sessions where assignments could be turned in, new ones picked up, and points of general concern could be discussed by the group with an instructor. In the general-assembly session, opportunity would be provided for students to meet the senior instructor, to hear special lectures by research professors, to view long films, to gain enrichment in the subject matter covered during independent study, and to set an intellectual tone for the course (67, p. 503).

The uniqueness of the audio-tutorial system of instruction lies in the fact that it both individualizes instruction and accommodates large numbers of students. Like programmed instruction, it requires that emphasis be placed on clearly defined learning behaviors rather than on teaching objectives as commonly interpreted by subject-oriented instructors. But unlike early forms of programmed instruction, the system makes use of a variety of instructional media, each according to its appropriateness to specific learning requirements. Systematic analysis is required both to specify the needs and to determine the best means for meeting them (67, p. 508).

As a result of constant evaluation of the audio-tutorial botany course, a number of advantages become clearly evident. Postlethwait (41,
pp. 186-187) summarizes them as follows:

1. Emphasis is placed on student learning instead of teaching technology. The student receives credit for his knowledge and skill regardless of how or where it was acquired (attendance does not contribute to the grade).

2. The study pace is under control of the student. He can repeat or omit any portion of the study program he desires.

3. Better students are not a "captive audience". They are free to choose those activities which are most instructive and challenging.

4. Study time can be arranged to accommodate the demands of other campus activities or work loads.

5. Study conditions involved a minimum of distraction.

6. Contact with instructors are meaningful and at a time when the student has a "readiness to learn".

7. More students can be accommodated with less space and with less staff.

8. Students learn more in less time. Grades are higher and "feedback" from past students indicates that retention is better.

9. Problems with make-ups are minimized.

10. The student is treated as an adult who is capable of participating in decisions concerning his study habits.

The student's response to this approach was overwhelmingly positive. The results on one unsigned questionnaire show that 96 percent of the students have a preference for the audio-tutorial system over the conventional arrangement. The relaxed atmosphere of independent study permits the students to explore topics of individual interest thoroughly and to master techniques and understanding before proceeding to the next item. This results in improved student performance as evidenced by overall higher grades and by student enthusiasm for the subject.

Some additional advantages which Postlethwait (42) further suggests
are:

1. Appropriately sequences and integrates the use of printed texts and manuals, movie films, microscopes, specimens, — every conventional learning event.

2. Ideally accommodates students with a wide diversity of backgrounds, aptitudes, and interests;

3. Places the mechanics of scheduling and the responsibility for learning on the students.

4. Leaves the teacher free for real business of teaching — orientation, direction, elucidation, guidance, and personal contact with the individual students.

The audio-tutorial system has been in operation at Purdue since the fall of 1962. Over 2,500 students have been exposed to botany through this system and over 90 percent have indicated a preference for this approach over the conventional system in unsigned questionnaires. The author has taught general botany at Purdue for more than 16 years, and estimates that the current course contains approximately 50 percent more information than previously and the students' understanding of course content is much improved. The average amount of time spent in an Independent Study Session (ISS) per week per student for the entire semester is a little over two and one-half hours, and this is in contrast with four hours per week spent by each student under the conventional system (33, p. 317). The result of the audio-tutorial approach as reflected in the performance of the students during the past four years has been improved learning at all levels. A's increased from 7 percent to 22 percent, B's from 20 percent to 35 percent, and F's have decreased from 20 percent to 7 percent (45, p. 659).

Students vary widely in the time they require to master a given body of knowledge. In a preliminary study (47, p. 103) of differences in
information acquisition rates for botany students, it was found that time spent in the audio-tutorial booth was related to the total scores on tests of botanical knowledge. However, the relationship was much more striking when the group under study was divided according to analytic ability, i.e., students scoring in the upper, lower, and middle thirds on a test of analytic ability were treated as distinct groups. It was noted that hours of study in the audio-tutorial booth, a principal learning experience for most students, show a positive correlation with the score on a 100 item test of botanical factual knowledge. However, when grouped by analytic ability, it can be seen that knowledge gained by the middle analytic group was greater for a given amount of study time and knowledge scores for the high analytic group were higher than for the lower two groups, with means scores for high analytic group working in the booth only nine hours in a five-week period exceeding the mean scores for students in the middle analytic group working for 20 hours in the same period.

Each instructor must consider his objectives and evaluate his procedures in each lesson prepared for a course. The audio-tutorial system forces an instructor to spend a great deal of time in planning the preparation of each lesson. Postlethwait (43) suggests seven steps in the preparation of the audio-tutorial lesson:

1. "List all of the objectives of the unit". The teacher should list the possible achievement which he expects the students to accomplish.

2. "List all of the available media and teaching aids which might be useful in accomplishing the above objectives". These include all items that might be useful in this regard such as: exercises to be completed from a manual, films to be viewed, homework problems to be completed, etc.
3. "Select the media adapted to the subject". List alongside the items to be accomplished, the method through which they can best be done.

4. "List the study activities in their proper sequence". Align each item in a properly programmed sequence.

5. "Assemble the materials to be programmed by the audio tape". This should result in the production of a trial tape.

6. "Have the audio tape transcribed and edited critically". This step enables the instructor to make sure the words he uses express precisely the information he wishes to present and to eliminate much of the redundancy which occurs in ordinary conversation.

7. "Make the final tape". The final tape may best be made from a manuscript which has been edited.

While it is true that there is much to discover about the learning process, we should consider the sequencing of learning events with each objective identified and as by the nature of the subject matter. Postlethwait (45, p. 660) in his article, Multi-faceted Approach to Teaching, the Audio-Tutorial Approach, summarizes his feelings about the approach to teaching as he states:

Education is a science, and one may begin as with any other problem by clearly defining the problem first. Once the problem is defined, the solution is often evident. Basically the problem is to help the learner learn, and since learning must be done by the learner, one should design all activities to require involvement of the learner with a total focus on what objectives are to be achieved, the facilities available to achieve these, and how this person as an individual can best approach or grow to acquire the desired characteristics. If audio is eliminated as a pathway, the many other facilities and communication devices must be exploited.

A Review of Related Research and Ongoing Audio-Tutorial Projects

Since the initiation of the original study conducted by Postlethwait using audio-tutorial instruction, only a few experiments have been
completed comparing the effectiveness of audio-tutorial versus a traditional method of instruction. The conclusions of most investigations are the result of questionnaires from students and instructors who expressed opinions as to how the courses actually were conducted.

Ted E. Surdy (55), Kansas State Teachers College, Emporia, Kansas, has been using audio-tutorial instruction in a bacteriology course for over two years. This experiment combined the lecture and laboratory content into one individualized course. Every effort was made to prepare tape recordings which were designed as a personal discussion of a problem rather than a lecture. The success of the program has been due to the close contact between the instructor and student. He (55, pp. 15-16) feels additional benefits derived from the system is the maximum utilization of staff, more efficient utilization of space, and the simplified laboratory arrangement. The most important benefits are the individualization of instruction, the empathy established between student and instructor, and the return to the student of much of the responsibility for learning.

Various concerns by the faculty of the College of Agriculture at the University of Illinois led staff members to develop an audio-tutorial carrel that could combine audio and visual media. Behrens and Harmon (7) of the Animal Science Department volunteered to prepare subject matter material to be developed into experimental units for Animal Science 303, Pork Production. The experimental units were put into use the last three weeks of the spring semester. At the end of the term, the students were asked to provide informal evaluations of the program in terms of subject matter and equipment.
Evaluations of the courses being taught by this method show the following (7, p. 452):

The main advantages of this system are one-time preparation and individual study. The instructor can make a more thorough presentation of subject matter and can make corrections before presenting the material. Demonstrative material can be prepared outside the classroom once and presented repeatedly, and events controlled by biological timing can be presented at any time. Students can cover the materials at their most efficient pace, even repeating if necessary, and they have unobstructed viewing. Classroom time is freed for discussion. Updating the material is a simple procedure. Finally, the system provides a framework for coverage of additional objectives for gifted students.

H. C. Smith and L. N. Skold (52, p. 147), University of Tennessee, collaborated on reviewing the independent study which has replaced all of the laboratories and most of the lectures in an introductory course in plant science for agricultural students. The "learning center" is a modified laboratory with student carrels, booths for slide and film projectors, and tables for demonstrations. Through a coordinated system using audio tapes, workbooks, living plants, plant products, microscopes, slides and single-concept films the students are guided through a series of study activities. Two years of use and evaluation indicate that most students prefer the method over conventional lectures and laboratories. Among the advantages of the system are: (1) students can study at their own speed and at a time most convenient to them, (2) learning and retention are improved through repetition, (3) the use of many different communication devices stimulates interest and maintains attention, (4) increases student's ability to study and emphasizes the development of personal responsibility, (5) increases enthusiasm and interest of instructors, and (6) the system requires less space, equipment, and staff time after its
Detroy E. Green, associate professor of agronomy at Iowa State University, initiated, on a trial basis, the audio-tutorial method of laboratory instruction in Agronomy 114 in the fall quarter of 1966. The laboratory had previously been changed from the conventional to a station type of instruction during the winter quarter of 1965-66 and student test scores increased 4 percent. Two sections of approximately 25 students each were randomly selected each quarter to be taught by the A-T method. Test scores were compared with students receiving station type instruction. A lower percentage of students dropped the course in the A-T sections, 4.14 percent as compared to the sections with station instruction, 6.19 percent. The weekly grades for the A-T method were higher, averaging 77.7 percent in fall, 83.7 percent in winter, and 81.8 percent in the spring quarter. Grades in the station instruction averaged 71.7 percent, 73.8 percent, and 72.7 percent for the three quarters.

The final examination scores averaged approximately the same for the two methods in all three quarters. The variance of the weekly and final examination scores was greater for the station method of instruction. More than 20 percent of the students in the station type instruction and 10 percent in the A-T method made grades averaging below 70 percent. Approximately 17 percent of the students in the A-T section made grades of 90 percent or higher and only 9 percent of the students in the station method achieved this level of performance (58, p. 148).

Green cited in (57) feels that the only limit to this type of teaching approach is money, time, and instructor imagination.
A further analysis of the Green program was conducted by Mr. James Lee (29) as he used a two-factor analysis of variance technique in comparing the audio-tutorial approach to the traditional laboratory method of instruction. Analysis of data as a growth measure over the period of each academic quarter and then over the whole year using laboratory quiz means, laboratory final exam, and course grade after they were adjusted for the pre-test. This resulted in a highly significant difference in favor of the audio-tutorial sections.

In 1968, Stuck (54) conducted a study at Iowa State University to determine the effectiveness of audio-tutorial method of teaching school law to pre-service teachers as compared to the lecture method of instruction. This experiment was conducted during the fall quarter 1967 using 219 students enrolled in Education 426, Principles of Secondary Education. The analysis of the experiment can be defined as a multi-factor analysis of variance with repeated measures on subjects. The factors consisted of group, achievement level and student teaching experience, while the measures were pre-test, post-test, and retention test. He found that the only measure showing any significance was in the two methods of instruction. The results indicated that the audio-tutorial method of instruction was significantly better than the lecture method.

As of this date there appear to be very few completed research projects utilizing controlled conditions with audio-tutorial techniques. Within the past few years many institutions have incorporated the audio-tutorial approach into various subject areas of their curriculum. A review of these ongoing projects identifies additional cautions and benefits. A review of a sampling of the ongoing projects is presented in
the following section.

Writers (49) at the University of Guelph, in discussing the audio-tutorial botany course which has been highly successful, presents several aspects of the program favorable to staff utilization and costs. The findings show the audio-tutorial system to be more economical in the use of professional-ranked personnel. Under their system the instructional staff became totally involved in the course and the quality of instruction increased tremendously. As the class size increased, there was not a progressive increase in instructional cost per student as compared to the lecture-lab cost for instruction up to 350-375 students. Above this figure the financial effort expended per student becomes progressively less. He concluded that the audio-tutorial format had increased the total cost of instructors somewhat and lowered slightly the student-staff ratio in 1967-68. However, the audio-tutorial arrangement has increased the efficiency of use of equipment and that the costs would remain fairly static, with a doubling of the class enrollment.

Students in Biology 101, Principles of Biology, at the State University College at Brockport, New York, have one thing in common—they are all students using the new Tutorial Center in the Department of Biological Sciences. The audio-video-tutorial program in biology integrates many materials, tools, and processes of a biologist in inquiry, such as textbooks, study guides, single-concept 8 mm. and 16 mm. motion pictures, demonstrations, individual experimentation, single-concept television video modules prepared by the tutorial professors in the science television studio, microscope observations of plants and animals, closed circuit television, and self-evaluating techniques. All of these media
are designed to supplement faculty-study relationships.

Researchers (56) reveal that the emphasis in the program is on student involvement in reaching the goals set up for the course—the understanding of a specific group of principles of biology. Self-evaluation is an important aspect within the structure of this tutorial program.

After the student has completed the study prescribed in the tutorial center, and when the student feels that he understands the principles involved, he has the opportunity to evaluate his own achievement. This is made possible through the use of a booklet of questions and answers. Since the questions concern what is believed to be important for the student to understand, the student is intrinsically motivated to make a careful evaluation of his own understanding. All students report to the self-evaluation center at some time each week on a volunteer basis.

J. T. Head and O. Runquist (51, p. 407; 21, p. 53) delineate some of the advantages of their two-year program in chemical laboratory techniques. The attractive features they found about the audio-tutorial approach to a programmed laboratory are: (1) Most of the laboratory procedures can be presented at a time when students are most receptive; (2) The lecture about a particular reaction or procedure can be given when a concrete example is before the students, and the lecture is given during laboratory time which is generally wasted; (3) The tape can pace the students and encourage them to make the best use of limited time; (4) The instructions given by tape can become less and less detailed as the laboratory course proceeds thus forcing the students to become more and more independent; (5) The laboratory instructor is freed from many of the
small details involved in laboratory instruction and can concentrate on helping individual students; (6) Considerable time can be saved by eliminating pre-lab periods, by transferring the discussion of certain reactions from the lecture to the laboratory, and by helping students budget laboratory time.

While the programmed laboratory is very useful in teaching techniques and procedures, we feel that the creative aspects of a laboratory course must be developed by other means.

B. F. Richardson (48) reported the characteristics of the new method of instruction as being used in the two-semester freshman Elements of Geography course at Carroll College. The entire course is presented by means of taped discussions and colored slides. The laboratory work in the A-V-T system logically and immediately follows the lecture topic, and it thus becomes an integral part of the course, rather than an appendage to it, as is frequently characteristic of the more traditional lecture-discussion-laboratory type of presentation.

Each Monday a major in-depth examination is administered. After one semester of operation the distribution of examination grades in the course was 18 percent A, 35 percent B, 33 percent C, 9 percent D, and 5 percent F, or about 16 percent higher than the average over a ten-year period under the traditional method of instruction. During the first semester, there developed a relationship between the length of time a student spent in the A-V-T booths and his examination score. The students scoring below "C" on examinations spent about half as much time in the booths as those scoring above "C".
Currently engaged in a curriculum resource development program designed to produce a wide range of materials and procedures for the teaching of introductory physical geography is B. F. Richardson. He characterizes geography as using visuals, especially maps, both as research tools and as instructional media more than most other disciplines to explain the complex spatial relationships which exist at scales too great to "experience" by other methods. So many of the basic concepts of geography such as area differentiation, patterns of distribution, regional interaction, diffusion and dispersion readily lend themselves to visualization and, as a result, are more quickly and completely understood. He (6) believes that a discipline which has these characteristics is a "natural" for the audio-tutorial approach, provided the proper programs and materials can be developed to fit the system.

Dr. Curl (12) of Western Michigan University reports that students like the self-instructional, audio-visual-tutorial method of instruction. Ninety percent of the students recently completing a self-instructional physical geography course at Western were "very satisfied" or "satisfied" with the AVT course: 94 percent of the students would prefer AVT to the conventional, large-group lecture course; 78 percent would prefer individual self-instruction to a conventionally taught lecture course with smaller sections.

The Jefferson College English Department (32) adopted S. N. Postlethwait's audio-tutorial program to emphasize basic punctuation, sentence, and paragraph development. They utilized the language laboratory to defray initial costs of the program. All students who were below the 25th percentile on state college norms were required to enroll in the
course. The program had built-in review and reinforcement. After each student had received the corrected theme, he was assigned to listen to appropriate tapes and rewrite the theme. The advantage to this system, it is felt, is that the students spend more time in solving their own problems.

The group tutorial approach using programmed instructional materials is designed to provide the best take-off between cost and effectiveness to overcome the problems inherent in large group instruction. Perhaps the largest single commitment to this approach is in Oakland Community College in Bloomfield Hills, Michigan. All the principles of group tutorial instruction have been given a unique environmental application in this school. On this campus, one building contains three classrooms that accommodate 3,000 students. The remainder of the building contains 600 individual carrel positions employing audio tutorial devices. Students can spend four-fifths of their time directing their own learning using these carrels and can call in individual tutorial assistance on points they may fail to understand. The school has attempted to integrate the most efficient principles of individual learning with the highest degree of efficiency possible.

J. E. Tirrell (60) explains that Oakland's system is based on the fullest knowledge of learning procedures and is built around the theory that, if a student knows where he is going and how to get there, he will get there if he wants to. Oakland sees its role as giving help and motivation. He (61, p. 21) defines the system as a learner-centered or a "closed loop" model of instruction. It is a self-adjustive performance system based specifically on the pre-definition of (1) what is to be
learned, (2) the required levels of terminal or final proficiency to be achieved by learners, and (3) the most appropriate sequence of instruction for learners to insure their success on each progressive step leading to the attainment of the prestated performance specifications stated in behavioral terms.

Use of an auto-tutorial program in a mathematics unit for Delta College nursing students resulted in a favorable student reaction and a higher percentage of success than in a group taught by conventional methods. This success led to the development of 8-millimeter films, accompanied by audio explanations on tape, for demonstration of nurse's techniques and complex situations which are not ordinary study material in the traditional classroom. The student using the equipment was able to stop the process at any time for close study, and he could review the learning experience as many times as desired. It was expected the process would (1) release instructors to give individual instruction and supervision, (2) utilize faculty in teaching greater numbers of students without loss of instructional quality, (3) permit students to progress at their own optimum speeds, and (4) facilitate the use of the materials beyond the college where they were developed (27).

The purpose of a Title III project under the guidance of Higgins and Rusch (22) was (1) to develop educational media for teaching educable mentally handicapped children in arithmetic concepts and (2) to evaluate the developed programmed instructional materials. During the first phase of the study the activities were devoted toward accomplishing the first purpose, developing the equipment and materials. Several devices and
combinations of devices were used during the trial period. The device finally developed, referred to as the audio-visual-manipulative (VM) desk, presents information on a screen through the use of the slide projector. Audio messages are transmitted through earphones and a speaker, and the child manipulates objects or writes on the response surface. Twenty-one different sequential arithmetic programs were developed for the desk for teaching EMH children skill sequences in arithmetic. Desk administered tests were also developed to assess the child’s understanding of these concepts. Other materials developed include (1) A manual of instructions for teachers (which includes the program objectives) and (2) reinforcement materials for classroom use. During the evaluation phase of the study, four separate field studies were conducted. The results of these studies show -- (1) AVM system was an effective variable in producing differential results, (2) going through the programs twice did produce higher post-test scores than going through the program once, (3) the system could be used effectively in a classroom setting under the supervision of classroom teachers, and (4) programs developed for EMH (Educable Mentally Handicapped) children were not appropriate for trainable mentally handicapped children.

A 1966 workshop under the direction of Dr. Luis E. Folgueras (17) dealt with the preparation of auto-tutorial laboratory techniques for nursing training for graduates, students, aides, and patients. Tape recorders, forms, transparencies, and other audio-visual aids bring discussion, demonstration, and practice into close sequence. They are useful (1) in the presentation of many nursing procedures, (2) in preconditioning
the student to traumatic sights, (3) in clarification or added comprehension of lecture materials, (4) in presenting interview techniques, (5) in providing immediate feedback and thereby strengthening student-instructor relationships, and (6) in allowing more effective use of faculty in teaching increasing numbers of students. The student sets his own pace and, within reason, may take his test when ready. This has several positive results -- (1) his motivation is maintained, (2) he gains satisfaction by showing that he is sure of his knowledge, (3) he is not frustrated by working beside slower or faster learners, (4) he can use the instructor's time more flexibly, and (5) he finds no fluctuation in the quality of his instruction.

We cannot expect the audio-tutorial approach to have a significant impact on instructional practices or procedures until there is less resistance to change. It appears that a breakthrough is evident due to the large number of schools trying to utilize this approach.
METHODS AND PROCEDURES

The problem of this investigation was to determine if audio-tutorial materials could be developed for instruction of seventh grade mathematics students and to evaluate (test) the efficacy of these materials in the Boone Junior High School. An additional aspect of the study was to determine if audio-tutorial instruction was significantly different from the traditional type of instruction.

This chapter describes the methods and procedures that were used to gather and analyze the required data for the study. This chapter has been divided into five parts: (1) Selection of the population for the study, (2) Preparation of the materials, (3) Class management and experiment execution, (4) Testing, and (5) Treatment of the data.

Selection of the Population

The Mathematics Seven course is required of all students in seventh grade attending the Boone Junior High School. Traditionally students have been enrolled in this course for a period of one year. At the completion of sixth grade all of the students were evaluated by the instructors on past performance in mathematics, ability and test results. On the basis of this evaluation, 52 students were assigned to accelerated mathematics classes for their seventh grade year.

Once the accelerated classes were determined, the actual selection of the control and experimental groups was completed. The remaining 139 students were randomly assigned to class sections by a computer scheduling service in Des Moines, Iowa.
It was decided that since there were three teachers involved in teaching the six sections of students involved in the study, each teacher would have a control and experimental section. The control and experimental sections were assigned to the teachers on a random basis.

Preparation of the Materials

Once the decision had been made to teach seventh grade mathematics by the audio-tutorial method, it was necessary to develop materials which could be used by this technique. This particular group of students was selected in order that this type of instruction could be carried on grade by grade if the technique proved successful.

A brief background of the events leading up to the actual implementation of the study is necessary.

Miss Rosemary Hall, seventh grade mathematics instructor, was employed during the summer of 1968 to prepare the materials and to assist in having them put on audio-tapes. The basic source to be used was the seventh grade textbook, Modern School Mathematics, Grade 7, in the development of the basic audio-tutorial materials. This particular textbook was also to be utilized by the control groups as their basic source of instruction.

It was the responsibility of Miss Hall to develop the lessons for each chapter, dialogue for each taped lesson, and basic overlays composed of explanatory materials. Supplemental exercises for each unit were developed by Mr. Friedrich, senior high mathematics instructor.

Each lesson was first prepared on the dictaphone. A student secretary
prepared a copy of the dictaphone belts and this copy was corrected and revised by the instructor. A master tape of the lesson was prepared from the corrected copy.

The services of Iowa State University were utilized to reproduce ten copies of each taped lesson, which is adequate for classes of 26 to 30 students. Student help was employed to cut these tapes and arrange them on reels to be used in the audio-tutorial laboratory.

Overlay packets were developed which included materials usually written on the blackboard. Students employed in the Boone instructional materials center produced overlay packets to accompany each of the taped lessons for each of the ten tape reels.

Two to five supplemental lessons were developed to accompany each chapter. These are provided as optional exercises and are intended to provide extra stimulation for the students who work at a faster rate in each class. Individual programmed practice books are provided for individual review work to supplement the chapter material.

With the concept of individual student learning within the class as the basis for the audio-tutorial class, ten complete copies of the solution key have been provided so that students may correct their own work and discuss their errors with the instructor on an individual basis.

An audio-tutorial laboratory (see Appendix E) equipped with ten audio booths and six extra stations was constructed adjacent to the mathematics classroom. Storage for tapes and lesson materials, adequate equipment and table and chair seating were assembled prior to the beginning of the experiment.
Class Management and Experiment Execution

The experimental group was subjected to an orientation session during the first class meeting. While this was taking place the control groups (those being taught by the lecture method) began their first hour of class instruction. The orientation dealt with two different aspects of the class. The first dealt with giving the students instruction in the proper technique of operating the tape readers and the location/arrangement of the necessary tapes. The second phase concentrated on the proper mechanics a student must follow throughout the course. A student would go into the audio-tutorial laboratory and pick up a chapter assignment sheet and the tapes corresponding to the lesson he was to study. The student would follow the explanation and direction given by the tape which corresponded to the textbook and assignment sheet.

The assignment sheet contained material and directions which cover the entire chapter. All students spent a specified length of time on each chapter. Each student could work at his own rate during this period of time and possibly finish the required material in a shorter period of time. A student who would finish the material before the allocated time could do supplemental work or individual programmed instruction for review. All students had a day of oral and blackboard review with the instructor before the final chapter test was given.

At the beginning of a new chapter it was necessary to use two listening centers which would allow eight students to use one taped lesson at the same time. After the first day the students were working at different rates and the demand of students for the same tape was considerably
reduced.

Each student in the experimental group was able to come to the audio-tutorial laboratory anytime during the day the lab was unoccupied and they had nonscheduled time or study hall. Several of the students used the lab before and after school. A high school student served as the laboratory monitor whenever the instructors were not available. The monitor had charge of the materials and assisted with the equipment. The students were able to review materials previously completed or work ahead as they desired. The students in the control groups met only during their regularly scheduled class periods.

Testing

The testing was done in two different phases. The pre-test was given at the end of the 1967-68 school year, when the students were completing the sixth grade. All new seventh grade students were tested immediately upon entering the seventh grade with the same pre-test materials. These tests were corrected and scored by the class instructors. The post-test was given at the completion of the first semester of the 1968-69 school year.

The students in the audio-tutorial groups were given a questionnaire at the completion of the first chapter in which they were asked for suggestions and improvements of the program. At the termination of the first quarter the audio-tutorial students were again given a questionnaire requesting suggestions and recommendations related to audio-tutorial instruction.

Finally, an attitude questionnaire was given to the students at the
time of the post-test in which they were asked their impressions of the audio-tutorial techniques as they saw them.

Treatment of Data

The primary goal of the investigation was to evaluate the relative effectiveness of the audio-tutorial method of instruction to the lecture method, as measured by the post-course mathematics achievement test, when initial differences between the two groups have been adjusted with respect to the achievement pre-test, group intelligence tests, and grade point average. It was also desired to investigate whether the effectiveness of the two methods differed by two classifications of the students: (1) whether or not the student had been instructed by teacher 1, 2 or 3, and (2) sex of the student.

Table 1 indicates the number of students contained in the three-way classification, group (experimental and control), by sex of the student, and by teacher 1, 2 or 3.

Table 1. Experimental subjects by group, sex of the students, and instruction by teacher 1, 2 or 3

<table>
<thead>
<tr>
<th>Group</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$T_1$</td>
<td>$T_2$</td>
<td>$T_3$</td>
</tr>
<tr>
<td>Experimental</td>
<td>19</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Control</td>
<td>13</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>22</td>
<td>20</td>
</tr>
</tbody>
</table>
The analysis for the experiment can be defined as a multifactor analysis of covariance. This technique will allow a study of the performance of these six groups which are unequal by equating statistically the dependent variables of pre-achievement test, intelligence test, and grade-point average.

The main effects of this experiment consist of group, sex of the students, and teachers. The measure of the experiment was the post-test mathematics achievement score.

The basic model including effects and the sources of variability isolated in the experiment is:

\[ Y_{ijkl} = \mu + G_i + T_j + e_{ij} + S_k + GS_{ik} + TS_{jk} + \epsilon_{ijkl} \]

where:

- \( Y_{ijkl} \) = Achievement score on the post-test
- \( \mu \) = Over all grand mean
- \( G_i \) = Effect of group, \( i = 1 \) for experimental, 2 for control
- \( T_j \) = Effect of instructor, \( j = 1 \) for teacher 1, 2 for teacher 2, 3 for teacher 3
- \( e_{ij} \) = Effect of interaction of the ith group with the jth teacher which is the error term for comparison of classes
- \( S_k \) = Effect of sex of the student, \( k = 1 \) for male, 2 for female
- \( GS_{ik} \) = Interaction effect of the ith group with the kth sex of the student
- \( TS_{jk} \) = Interaction effect of the kth sex of the student with the jth teacher
\( \delta_{ijkl} = \text{Random error} \)

The raw data relevant to this model were placed on code sheets and then punched and verified on IBM cards. The facilities of the Iowa State University Computation Center were used to analyze all the data on the 360 IBM machine. For a description of the procedure applicable to the model used, see Chapter 7 in Winer (66).
FINDINGS

Introduction

The findings of this study are based upon the results obtained by testing 139 students in the Boone Junior High School seventh grade and their response to three questionnaires completed during the course of the experiment.

In the findings related to this study, two categories are discernible: (1) analysis of the data by testing, and (2) the response to the questionnaires. Consequently, such a division has been made in the following discussion.

Analysis of Data by Testing

Five null hypotheses were to be tested as set forth in Chapter One under the statement of the problem. Three questions were also to be considered. The questions, which call for conclusions, will be discussed in the final chapter. Information relevant to these questions has been obtained through the examination of the questionnaires.

The experiment was to compare groups of students exposed to two different teaching techniques. Individual differences among the members within the groups were suspected to influence each teaching technique, therefore, to attain a measure of control of these differences, analysis of covariance was utilized. The covariates (control variables) used were: intelligence quotient, grade point average and pre-test score.

Since the number of students within the group-teacher-sex classifica-
tions were unequal, an approximating technique was used in the analysis. The mean post-test score for each of these 12 classifications, adjusted for the three covariates, was estimated. This procedure involved fitting dummy variables, representing the classifications, and the three covariates against post-test scores for all 139 students by multiple regression techniques. Table 2 reports these adjusted means for the 12 classifications. The effect of the procedure is essentially the same as covariance analysis in that the resulting mean values of the post-test score for each classification are adjusted to a common value of the three variates, intelligence quotient, grade point average and pre-test; therefore, any initial differences among classifications are eliminated from the comparison of post-test scores.

Table 2. Adjusted post-test means as adjusted for intelligence quotient, grade point average and pre-test scores

<table>
<thead>
<tr>
<th></th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Teacher one</td>
<td>85.22</td>
<td>80.98</td>
</tr>
<tr>
<td>Teacher two</td>
<td>86.02</td>
<td>83.05</td>
</tr>
<tr>
<td>Teacher three</td>
<td>83.44</td>
<td>80.43</td>
</tr>
</tbody>
</table>

The five null hypotheses were tested, as a part of the overall analysis of the study, and the analysis of variance is presented in Table 3. The analysis failed to reject any of the null hypotheses which were:

There will be no significant difference in the post-course mathematics achievement of the audio-tutorial and traditionally-taught students; there
Table 3. Analysis of variance of adjusted post-test means

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (G)</td>
<td>1</td>
<td>18.36</td>
<td>18.36</td>
<td>5.26</td>
</tr>
<tr>
<td>Teachers (T)</td>
<td>2</td>
<td>1.10</td>
<td>0.55</td>
<td>1</td>
</tr>
<tr>
<td>Error₁ (Classes within G and T)</td>
<td>2</td>
<td>6.99</td>
<td>3.49</td>
<td>--</td>
</tr>
<tr>
<td>Sex (S)</td>
<td>1</td>
<td>15.92</td>
<td>15.92</td>
<td>4.52</td>
</tr>
<tr>
<td>(S) x (G)</td>
<td>1</td>
<td>3.64</td>
<td>3.64</td>
<td>1.03</td>
</tr>
<tr>
<td>(S) x (T)</td>
<td>2</td>
<td>11.40</td>
<td>5.70</td>
<td>1.62</td>
</tr>
<tr>
<td>Error₂ (G x S x T)</td>
<td>2</td>
<td>7.04</td>
<td>3.52</td>
<td>--</td>
</tr>
</tbody>
</table>

will be no significant difference in the post-course mathematics achievement of male and female students; there will be no significant difference in the post-course mathematics achievement among the students who have been instructed by a different teacher; there will be no significant difference in the post-course mathematics achievement between the interaction of teaching technique and sex of student; and, there will be no significant difference in the post-course mathematics achievement between the interaction of sex of student and teachers, when in each null hypotheses the initial differences between the two groups have been adjusted with respect to initial knowledge of mathematics (achievement pre-test), intellectual aptitude (group intelligence test), and previous scholastic performance (grade point average).

After adjusted classification means were estimated, an analysis of variance of these means was used to test the stated hypotheses. Addi-
tional information deemed pertinent to this study, since all of the null hypotheses were not rejected, is presented in the following tables and discussion.

The effect of the covariates upon the actual mean of the post-test and the adjustment which resulted is shown in Table 4.

Table 4. Effect of the covariates (intelligence quotient, grade point average and pre-test) on the mean of the post-test by classification

| Classification | Covariates | Post-test | | | |
|----------------|------------|-----------|---|---|
|                | IQ         | GPA       | pre-test | Mean | Adjusted mean |
| Experimental   |            |           |          | Mean |               |
| T₁, Male       | 100.26     | 1.78      | 78.89    | 81.10 | 85.22          |
| T₁, Female     | 103.28     | 1.80      | 83.28    | 79.85 | 80.98          |
| T₂, Male       | 103.58     | 2.06      | 84.92    | 86.50 | 86.02          |
| T₂, Female     | 110.09     | 2.16      | 91.54    | 88.72 | 83.05          |
| T₃, Male       | 98.00      | 1.65      | 82.73    | 80.27 | 83.44          |
| T₃, Female     | 109.36     | 2.44      | 85.63    | 83.81 | 80.43          |

Control

|                |            |           |          | Mean |               |
|----------------|------------|-----------|---|---|
| T₁, Male       | 101.85     | 1.83      | 77.46    | 83.61 | 87.91          |
| T₁, Female     | 106.71     | 2.18      | 83.14    | 84.07 | 83.31          |
| T₂, Male       | 96.90      | 1.69      | 77.20    | 77.30 | 83.35          |
| T₂, Female     | 105.36     | 2.37      | 85.18    | 88.81 | 86.89          |
| T₃, Male       | 107.66     | 2.08      | 89.89    | 91.56 | 87.53          |
| T₃, Female     | 105.27     | 2.18      | 81.27    | 84.45 | 84.99          |

These data illustrate the adjustments made for the individual differences within the classifications. For example, the mean for classification (experimental group, teacher one, male) was adjusted upward from 81.10 to
due to the lower intelligence quotient, grade point average and pre-test score in relation to the other classifications. The inverse was also true, since adjusted means were lower than the mean where the covariate averages were high.

The adjusted post-test means of the teaching technique (group) and sex of student, presented in Table 5, represent the interaction of group with sex. These are consistent with the results of the analysis of variance, since for each sex group, the mean post-test score of the control group was higher than that of the experimental group.

### Table 5. Adjusted post-test mean scores by group and sex of student

<table>
<thead>
<tr>
<th>Sex of student</th>
<th>Experimental</th>
<th>Control</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>84.89</td>
<td>86.29</td>
<td>85.59</td>
</tr>
<tr>
<td>Female</td>
<td>81.49</td>
<td>85.09</td>
<td>83.25</td>
</tr>
<tr>
<td>Average</td>
<td>83.19</td>
<td>85.66</td>
<td></td>
</tr>
</tbody>
</table>

This result suggests that there was little difference in the average achievement of students when grouped by sex - male and female - between the groups.

Table 6 contains information similar to that in Table 5. The only difference is that instead of representing the interaction of group with sex, the representation of interaction of teacher and sex is presented.

Again, this illustrates that the average achievement of students by sex when taught by different teachers reflects very little difference.
Table 6. Adjusted post-test mean scores by teacher and sex of student

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Sex of student</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>One</td>
<td>86.56</td>
<td>82.19</td>
</tr>
<tr>
<td>Two</td>
<td>84.68</td>
<td>84.97</td>
</tr>
<tr>
<td>Three</td>
<td>85.48</td>
<td>82.71</td>
</tr>
</tbody>
</table>

Response to Questionnaires

The initial organization of an audio-tutorial course is critical to its success. In light of this criteria it was felt that the students should have an opportunity to react to this teaching technique. The students' response to the three questionnaires (Appendix C) was to be their contribution to this method of teaching.

The students' cooperation was evident in the thought that had gone into their comments on the first two questionnaires. As a result of these suggestions some revisions were made in the materials which were to be used later in the course.

Questionnaire one

When Unit One had been completed, the students were asked to react to the following question, "What suggestions do you have for improving the system?" The responses were categorized into No response; tape recordings; need greater explanation of tape content; need additional prepared tapes; need additional answer booklets; and need additional
audio-tutorial booths and tape readers for all students. Table 7 indicates that a high percentage (61.97 percent) of the respondents had no suggestions at this time. Fourteen and eight hundred percent felt that additional explanation was needed of the tape content. The third largest group of students' suggestions was composed of seven who felt a need for separate audio-tutorial booths and tape readers.

Only five students felt the quality of the tape recordings needed improvement, three students felt a need for additional tapes, and two individuals desired additional answer booklets.

<table>
<thead>
<tr>
<th>Suggestions</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No response</td>
<td>44</td>
<td>61.97</td>
</tr>
<tr>
<td>Need greater explanation of the tape content</td>
<td>10</td>
<td>14.08</td>
</tr>
<tr>
<td>Need separate audio-tutorial booths and tape readers</td>
<td>7</td>
<td>9.86</td>
</tr>
<tr>
<td>Tape recordings (voice not clear, instructions too fast, sound improvement needed)</td>
<td>5</td>
<td>7.04</td>
</tr>
<tr>
<td>Need additional prepared tapes</td>
<td>3</td>
<td>4.23</td>
</tr>
<tr>
<td>Need additional answer booklets</td>
<td>2</td>
<td>2.82</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>71</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

These findings led to some revision in the content of the tapes which were forthcoming. Additional explanations of the tape content was the major improvement at this time.
Questionnaire two

The second questionnaire was given to the students at the completion of three units of work and coincided with the end of the first quarter of the school year. The purpose of this instrument was to get an idea of the students' feelings toward this type of instruction as well as additional suggestions which would help improve the course.

Table 8 reports the findings of the students' feelings toward continuing the audio-tutorial method of instruction. These data indicated that over four-fifths (85.92 percent) of the respondents wanted to continue with the audio-tutorial method of instruction at this time.

Table 8. Response of students to the choice of traditional classroom instruction or audio-tutorial instruction

<table>
<thead>
<tr>
<th>Response</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desire to continue with audio-tutorial instruction</td>
<td>61</td>
<td>85.92</td>
</tr>
<tr>
<td>Desire to return to the traditional type classroom</td>
<td>10</td>
<td>14.08</td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td>100.00</td>
</tr>
</tbody>
</table>

The number and percent of students who had additional suggestions for improvement of the course were described in Table 9. This information revealed that 51 (71.84 percent) of the students had no suggestions for improvement at this time. This was an increase of ten percent of the students who had no suggestions at the end of the first unit's work. Six
Table 9. Suggestions for the improvement of the audio-tutorial method of instruction at the completion of the first quarter of the school year

<table>
<thead>
<tr>
<th>Suggestion</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No response</td>
<td>51</td>
<td>71.84</td>
</tr>
<tr>
<td>Need additional time to complete class exercises</td>
<td>6</td>
<td>8.45</td>
</tr>
<tr>
<td>All students should complete each unit of work before an examination</td>
<td>6</td>
<td>8.45</td>
</tr>
<tr>
<td>Tapes should include more explanations and examples</td>
<td>4</td>
<td>5.63</td>
</tr>
<tr>
<td>Eliminate some of the classroom confusion</td>
<td>4</td>
<td>5.63</td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td>100.00</td>
</tr>
</tbody>
</table>

students felt that more time was needed to complete class exercises and that all students should complete each unit of work before the examination was given. Four individuals felt that the tapes should include more examples and that some classroom confusion should be eliminated.

Questionnaire three

This questionnaire was organized to help the students arrive at a total assessment of the course. This instrument was concerned with the different components of the course: tapes, assignment sheets, answer books, chapter reviews, overlay materials, listening centers, and so forth. Students not only could answer the questions, but were invited to make comments about most parts of the course. These comments will be used in reorganizing some areas of the course next semester. Only the
comments which appear relevant in reflecting student attitude about the course will be reported in this discussion.

In the examination of the questionnaire, it was found that no question received 100 percent response from the students. Also, a majority of the students did not make comments concerning various aspects of the program where requested. The discussion of this questionnaire reflects the incompleteness of answers within the collection document.

Tapes The questionnaire began with a sampling of the students' opinion on the tapes and how they were utilized. To the question regarding the presentation of the information, 46 students felt the material was presented about right, while 14 indicated it was presented too quickly and eight felt it was given too slowly. Forty-six of the students felt the information usually prepared them to study the material properly, 22 indicated that it was acceptable only part of the time.

When queried concerning the number of times the whole tape was replayed, the students indicated that: 13 never did replay it entirely; 22 replayed it once; 20, twice; eight, three times; and five, more than three times. On the other hand, 44 of the students replayed part of a tape more often than the complete tape, while 22 indicated that it was seldom that they replayed part of a tape. It was found that as the course progressed toward the end of the semester that 12 students replayed parts of the tapes more often than at the beginning of the year, 23 played them about the same number of times, and 23 tended to play them less often.

Fifty students indicated they were usually helped to understand the textbook material with the tape explanations, eight students were always
helped and ten indicated that they were seldom able to relate to the material as explained on the tape.

Indications were given by 63 students that they knew whose voice was on the tape, while only five gave a negative answer. Forty-six of the students indicated they felt Miss Hall was the teacher by hearing her voice on the tape, while 23 did not agree. It is interesting to note that these 23 were not in the classes Miss Hall taught.

Ninety-six percent of the students felt they had an opportunity to ask questions over any area of the tape they did not understand.

Although 42 percent offered no suggestions for improving the tapes, the remaining suggestions ranged from explain more material in each chapter to make them more interesting; from need more examples included to the tapes are too long.

Chapter outline or assignment sheets In the analysis of the assignment sheet as a means of guiding the work over the course of a unit, 46 students indicated they could not work effectively without it, while 22 students felt they could if the teacher gave a daily explanation or assignment. Sixty-two percent felt that the addition of review questions on the assignment sheet would be the most helpful. However, 38 percent indicated that they thought the questions would not identify important material used in testing situations.

The students gave an indication by their comments that the assignment sheets should include examples of problems and their solutions as helpful explanation to the class.
Answer books  
The answer booklets were provided so that the students could check their own answers to the problems worked in the textbooks. To the query, "Do you prefer to check your own work rather than the teacher reading the answers to you?", 78 percent answered yes. A second question, to find out if the answer books were used unfairly, was answered by 47 students that they definitely knew some students who copied from the answer book and 25 pupils indicated they were not aware of anyone being unfair.

Review  
From the response to the questionnaire, the review sessions conducted before the unit examination was a most beneficial part of the audio-tutorial program. With a few exceptions everyone thought this class period was time well spent.

Sixty-three of the 68 students responding to the usefulness of the unit review felt it was useful. All but two of the students indicated they had an opportunity to ask questions over areas they did not understand in these sessions. Since it was felt that students might profit more from a smaller group in reviewing, the students were queried as to their impression of a group of eight to ten students for review rather than the entire class. Seventy-three percent indicated they would rather continue with the entire class as an acceptable size group.

Overlays  
Much time and effort went into the production of overlays and explanations of materials which were supplemental to the tapes. Eighty-three percent of the students found this effort useful, important, and clear enough in helping to study the material. Thirty-eight percent
felt that these materials did not parallel the examples which the teacher would normally put on the blackboard. The main criticism was the lack of examples and the solutions to them rather than the quality of those which had been produced.

**Listening centers** It was necessary at the beginning of each new unit of instruction for several students to share one tape by means of the listening centers. When asked if they would prefer to use the tape alone, 47 students responded yes, ten chose the listening centers, and 11 indicated they had no preference. When asked to give their opinion about the listening center the most common comment against them was: "too many students work at a different rate than I do and too much confusion results when the tape is reversed."

**General** The purpose of the questionnaire was to give the students a chance to assess various segments of the program first, and then to reflect on the total program. To a general question, asking the students to give their opinion regarding the overall course, the response indicated 46 students wished to continue the program. Several sample comments were as follows: "it keeps me busy all the time"; "I like to work alone"; "method very good"; "I wish I had more courses of this type"; "you can't replay the teacher". Dissenting comments ranged from, "I don't like it at all"; "too much confusion"; "I would like to go back to the old way of learning". To a yes or no question, the audio-tutorial format was preferred by 75 percent of the students over the traditional class method.

A second method of testing the attitude toward the course was by
asking the students if their marks accurately reflected the effort expended. Fifty-four percent felt that their marks were equal to the effort expended in the course. However, 66 percent still considered seventh grade mathematics a success, 28 percent felt it was unsuccessful and the remainder were sure it was only partially successful.

This questionnaire confirmed that the basic structure of the course was sound and the techniques which had been utilized were acceptable. Many useful and valuable suggestions were forthcoming which will aid in reorganization of the courses' weak areas.
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The problem of this investigation was to determine if audio-tutorial materials could be developed for instruction of seventh grade mathematics students and to compare the effectiveness of audio-tutorial instruction versus a traditional method of instruction.

As previously described, this study was comprised of two related parts. The first aspect of the study was by the use of statistical treatment of data to test the following null hypotheses: 1. There will be no significant difference in the post-course mathematics achievement of the audio-tutorial and traditionally-taught students. 2. There will be no significant difference in the post-course mathematics achievement of male and female students. 3. There will be no significant difference in the post-course mathematics achievement among the students who have been instructed by a different teacher. 4. There will be no significant difference in the post-course achievement between the interaction of teaching technique and sex of students. 5. There will be no significant difference in the post-course mathematics achievement between the sex of students and teacher.

The second aspect of the study was to use the results of three questionnaires administered throughout the course to determine the answers to the following questions: 1. Can a course in seventh grade mathematics be developed which utilizes the audio-tutorial method of teaching effectively? 2. How do audio-tutorial experiences affect the students' attitude toward the mathematics course? 3. Are students more highly motivated in mathematics when taught by the audio-tutorial
The sample studied consisted of 139 students (71 in the audio-tutorial sections) (68 in the traditional sections) enrolled in seventh grade mathematics in the Boone Junior High School during the first semester of the 1968-1969 school year. The traditional group was taught by the lecture method of instruction, and the experimental group was taught by the audio-tutorial technique using specially adapted materials and procedures. All the students were pre- and post-tested to measure growth over time.

The statistical technique, multifactor analysis of covariance, allows a study of the performance of the six groups of students which are unequal, by equating statistically the dependent variables of pre-achievement test, intelligence tests and grade-point average. The main effects of the experiment consisted of group, sex of students and teachers.

All the computed F-values were insignificant at either the .01 and .05 level of significance. Therefore, all the hypotheses could not be rejected for any of the factors or their interactions.

The students in the experimental group, although not performing significantly better than the traditional group, expressed a preference for the audio-tutorial method of instruction. Seventy-five percent of the experimental group indicated they wanted to continue this method of instruction.
Limitations

This study was limited to the seventh grade mathematics students, excluding the 52 top academic students, in the Boone Junior High School. The exclusion of these students was perhaps the most limiting factor of the study. This is the first course in the junior high mathematics sequence and any conclusion drawn from the study should not be generalized beyond this group.

This study examined two methods of instruction, audio-tutorial and traditional lecture procedure. Any comparison of instructional methods must be limited to these perimeters.

The content of this semester's work covered in this experiment focused upon concepts and material found in Units one, two, three, four, five, seven and ten in the textbook: Modern School Mathematics, Grade 7, Houghton Mifflin Company, 1968. The specific topics completed by the control and experimental groups were as follows:

Unit 1: Sets and Numbers

Unit 2: Properties of addition and subtraction in the set of whole numbers

Unit 3: Properties of multiplication and division in the set of whole numbers

Unit 4: Numbers and numerals

Unit 5: Algorithms of Arithmetic

Unit 7: Number Theory

Unit 10: Fractions and Rational Numbers

These units were only seven of several in the course; consequently,
discussions about methods of instruction for this course must be restricted to these specific units.

The facilities that were available for this experiment were such that each student did not have an individual study carrel and tape reader. Only ten individual student study carrels were available, and this necessitated the use of two listening centers during the beginning of each new unit. If there had been more individual units available, perhaps the students would not have been inconvenienced by sharing a single tape.

Another limitation was the number of periods a day which the audio-tutorial laboratory was available to the students outside of their regularly scheduled class period. Since the room was utilized all but two periods a day, students were compelled to use the laboratory before and after school, in addition to the two available periods. Because of this, it is probable that several students did not have the time or opportunity to use the laboratory when they needed it.

A retention test was not given after the post-test. If there had been a test given, we could have determined if there was a difference in the retention of the two groups.

Finally, the design of the study imposed some limitations in making inferences from the analysis. Since an analysis of covariance design with unequal cell sizes was employed, approximations of F values had to be made when testing for the significance of differences between groups. This procedure imposes the restriction that inferences must be made with caution.
Conclusions

As indicated previously, the problem of this study was to answer three questions and test five null hypotheses. The first question was; Can a course in seventh grade mathematics be developed which utilizes the audio-tutorial method of teaching effectively? The results of the study indicate that the audio-tutorial method of instruction was as effective as the traditional method with the following advantages:
1. There was more student-teacher contact. 2. The students were able to work at their own rate within an assigned unit of work. 3. Students were able to do supplemental lessons in addition to the regular class exercises when completing a unit of work early. 4. Students were able to review the concepts which were most difficult to them as many times as needed. When queried concerning returning to the traditional type of instruction, 75 percent of the students in the audio-tutorial group preferred this type of instructional organization. From this it can be concluded that a unit can be developed using this type of material and organization.

The second question asked how the experiences with this teaching technique affect the students' attitude toward the course. In the same light, question three was: Are students more highly motivated in mathematics when taught by the audio-tutorial technique? It was impossible to measure a specific criteria which would validate either of these two questions. Several indications of improvement in attitude and increased motivation came from the third questionnaire. Comments by the students expressing favor for the program were: "I wish I had more courses of this
type", "it keeps me busy all the time", "I want to continue this method", and "I think it's great". Another expression of a positive attitude was that 66 percent of the students in the audio-tutorial group considered mathematics a success; however, only 54 percent indicated they felt their marks reflected their effort. Finally, the teachers indicated that several students were putting forth more effort since they were coming to the laboratory during their unscheduled class time as well as before and after school.

The five null hypotheses were related to three factors (group, teacher and sex of student) and their interactions. On the basis of the findings in this investigation related to the null hypotheses, the following conclusions seem evident:

1. The audio-tutorial method of instruction for students did not result in a significant increase in achievement as measured by the California Achievement Tests.

2. The audio-tutorial method of instruction may have more efficiency over time, however, the procedures used in this study were limited to only one semester of a year course.

Recommendations

On the basis of this study and the audio-tutorial approach techniques suggested in the literature, the following recommendations are made for the seventh grade mathematics classes in the Boone Junior High School specifically:

1. The audio-tutorial method of instruction should be utilized to
teach seventh grade mathematics in the Boone Junior High School.

2. All teachers involved in teaching the seventh grade mathematics course should be involved in the preparation of the materials and the manner of its presentation.

3. The facilities of the audio-tutorial laboratory should be expanded so that each individual might have a study carrel and a tape reader. This would also eliminate much of the confusion which resulted from the use of the listening centers.

4. A retention test should be administered to the students completing the course to determine if there is a difference in the retention of the two groups.

5. If the audio-tutorial technique is used again, or if other mathematics classes are taught by this procedure, more related overlays should be developed and extra review materials, examples and solutions of problems should be included on the assignment sheets.

6. A rather comprehensive questionnaire should be developed to determine students' attitude toward the course. A statistical analysis should be made of the results.

7. Additional time should be made available for the students to use the audio-tutorial laboratory. It is suggested that students have access to a carrel in the center every period of the day.

Recommendations for Further Research

1. Replicate the study just completed. This would provide an opportunity to further validate these findings.
2. Complete another study similar to this, only use the entire seventh grade class, including the high academic achievers.

3. Duplicate this experiment using additional variations in procedure. An example would be to have sessions of large group instruction, small seminars as well as the independent study sessions.

4. Do the same type of study involving more audio-visual materials. Several possibilities exist for single concept films, movies, television and filmstrips.
BIBLIOGRAPHY


34. Miller, Elwood E. and others. Some of the ways audio visual helps teachers teach. Grade Teacher 82: 112-123. May, 1965.


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Appreciation is expressed to Dr. Richard P. Manatt for his assistance and guidance given me throughout the course of this project. I want to pay tribute to Dr. Anton Netusil, whose competent assistance facilitated the analysis of the data.

Recognition is given to the many people who have contributed to the successful completion of this study, with special acknowledgments to Dr. Ray Bryan, Miss Rosemary Hall, Mr. Don Reiminschneider, and the other members of my committee, Miss Julia Faltinson, Mr. Carl Hamilton, and Dr. Wallace Schloerke.

Finally, a special acknowledgment is expressed to my wife, JoAnn, for her patience and understanding during the course of this investigation.
APPENDICES

Foreword to the Appendices

Appendix A is a reproduction of the assignment sheets from units one, two, three, four, five, seven and ten, which are the guides to the specific material completed during this project.

Appendix B is a transcription of the dialogue of the tape for unit seven.

Appendix C is a reproduction of the three questionnaires which were submitted to the students.

Appendix D is an itemized listing of the costs incurred by the Boone Community School District in implementation of the audio-tutorial approach to teaching seventh grade mathematics for this project.

Appendix E is a diagram of the audio-tutorial laboratory as developed by the Boone Community School District.

A complete set of the materials that were used in the experiment is on file in the Math Department, Boone Junior High School, Boone, Iowa. Should anyone desire to inspect these materials, he should direct request to the above address or to the Principal's office of the same institution.
Appendix A: Assignment Sheets

MATHEMATICS ASSIGNMENT

UNIT ONE

<table>
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<tr>
<th>Starting Date</th>
<th>Review Date</th>
<th>Test Date</th>
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Use the tape which is labeled TAPE READER. It is on the machine. After each member of the class has used this tape, you may go on to the tape labeled INTRODUCTION 1-0.

Homework: Write exercises 1-16 on page 3.
Read pages 1-8 carefully.
Write the answers to 1-5 on page 6.
Start a vocabulary list in your notebook.

Lesson 1-1 Use tape 1-1.
Open your textbook to page 6 and follow the discussion on the tape as it refers to the text.

Homework: Do the oral exercises on page 8 immediately and check your answers before you leave class.
Write the answers to 1-14 on page 9.
Write the answers to the even-numbered exercises, 16-34, on pages 9 and 10.
Decide on the answers to the questions 1-4 on page 10.

Lesson 1-2 Check homework to 1-1. Discuss your errors with the teacher.
Use tape 1-2 and overlay packet 1-2.
Open your textbook to page 10.

Homework: Solve oral exercises, 7-22, and correct them before you leave class.
Write the answers to 1-10 on page 13 and 11-16 on page 14.
Draw a picture to show the relationship in problem 19.

Lesson 1-3 Check homework. The ice cream subsets are discussed on the tape.
Use tape 1-3 and overlay packet 1-3.

Homework: Keep your vocabulary list up to date.
Do the oral exercises on page 17 and check them before you leave class.
Write out problems 1-6 on pages 17 and 18 and write explanations for 11-16 on pages 18 and 19.
Use the red practice book to review sections 1-1, 1-2, and 1-3.
Lesson 1-4 Use the solution key to check the homework problems. Use tape 1-4 and overlay packet 1-4.

Homework: Make a Venn diagram for the insurance problem on page 19. Write the answers to the oral exercises 1-20 on page 22. Write the even-numbered exercises, 1-22, on pages 22 and 23. Make Venn diagrams when necessary for any of the above.

Lesson 1-5 Use the solution key to check the homework. If you do not understand, be sure to talk to the teacher. Use tape 1-5 and overlay packet 1-5.

Homework: Write the oral exercises 1-16 on page 26. Check them before you do the written exercises. Write the even-numbered exercises, 2-10, on page 26. Do all written exercises, 11-20, on pages 26 and 27. Use the prepared diagram sheet. Do the even-numbered exercises from 22-30 on page 27.

Supplementary Lessons:

Check the homework to lesson 1-5. Use the red programmed practice book to review 1-4 and 1-5. If you have completed the lesson ahead of the review date, then do the "Extra for Fun" supplementary lessons, 101, 102, 103. Please do not show other students your solutions. Let him find his own solutions. THINK

REVIEW Study the chapter summary and vocabulary list on pages 27 and 28. Write the answers to the chapter test on 28 and 29. We will discuss the chapter review on 29-30 together.

TEST Test over Chapter 1.

Homework: Study pages 34-37. Write the answers to the oral exercises on pages 37 and 38. If you do not understand some of the exercises, skip them until you can listen to tape 2-1.
Place a check in the blank before each assignment as you have it finished.

1. Study pages 34-37 in the textbook.
2. Use a Venn diagram to figure out the card confusion on page 34.
3. Listen to tape 2-1. Use explanation sheet 2-1 while you hear the tape. WRITE EXAMPLES WHICH ARE GIVEN ON THE TAPE.
5. Correct your work. Hand it in.
6. Read page 40 and write answers to 1-8 on page 40.
7. Listen to tape 2-2. Use paper and pencil to TAKE NOTES AS YOU LISTEN.
8. Write exercises 1-26 on page 43.
9a. Read page 44 and write answers to 1-8 on page 44.
10. Listen to tape 2-3. TAKE NOTES.
11. Do written exercises 1-26 on pages 48 and 49.
12. Do even-numbered problems 28-40 on page 49. If you do not understand the directions, ask for help.
13. Correct your paper. Hand it in.
14. Listen to tape 2-4. Have you learned to take notes without being told each time?
15. Write answers to 1-7 on page 50.
16. Write odd-numbered oral exercises 1-19 on pages 53 and 54.
17. Correct page 50 and the oral exercises.
18. Do written exercises 1-30 on pages 54-56.

19. Correct your work. Hand it in.

20. Listen to tape 2-5. Pencil in hand?

21. Write out 4 problems on inversions, bottom of page 56.

22. Write answers to oral exercises 1-8 and 13-20 on page 59.

23. Check the oral exercises and inversions.


25. Check your work and hand it in.


27. If you are ahead of the rest of the class, try the supplementary exercises 201, 202, and 203.

28. We will review Chapter 2 in class.

29. Test over Chapter 2.
MATHEMATICS ASSIGNMENTS
UNIT THREE

<table>
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1. Study pages 70-75 and write answers to page 70.
2. Locate cities on an Iowa road map.
3. Tape 3-1
5. Written exercises 1-28 on pages 74 and 75. Correct and hand in.
6. Read pages 75 and 76 and fill in the table on page 76.
7. Tape 3-2.
10. Tape 3-003.
11. Worksheet 3-003 on order of operations. Answers are on the next tape.
12. Tape 3-3.
14. Written exercises 1-20 on pages 83 and 84.
15. Study pages 84-87 carefully.
18. Written exercises 1-26 on pages 88 and 89. Correct and hand in.
18a. Tape 3-005.
19. Study the box puzzles on page 89.
20. Solve the empty box puzzles on 89 and 90.
21. Tape 3-5.
23. Written exercises 1-30 on pages 93 and 94. Correct and hand in.
25. Supplementary lessons.
26. Reviews (Write answers to the Chapter test on pages 96 and 97.)
27. Test over Chapter 3. (With remnants from Chapters 1 and 2.)
1. Tape 4-1. (This tape covers sections 4-1 and 4-2.)

2. Write out the even-numbered problems on page 107. Check them.

3. Write out all problems on page 111. Correct and hand in.

4. Tape 4-3.

5. Write out in words what you would say if you read 1-10 on page 114.


8. Study pages 115 and 116 and write answers to 1-5. Answers on tape 4-4.

9. Tape 4-4.

10. Write 1-8 on page 119 according to directions. Then multiply each part out and find the decimal numeral which is represented by each of the base two numerals.

11. Write out problems 13-20 on page 120. Check and hand in.

12. Do worksheet 4-4. Hand to teacher for approval before going ahead.

13. Tape 4-4A.

14. Write problems 1-12 on page 120. Check and hand in.

15. Do worksheet 4-4A and hand to teacher for approval.

16. Study sections 4-5 on page 120 and write the answers to 1-9. This is observation and thinking. Do not ask for help.

17. Tape 4-5.

18. Write the words which you would use to read 1-6 on page 123.
19. Write 7-14 on page 123 in expanded form. Correct and hand in.

20. Do worksheet 4-5 and hand to the teacher for approval.

21. Write 1-28 on pages 123 and 124 and hand in. Correct them.

22. Tape 4-6 and worksheet 4-6.

23. Do the written problems 1-4 and page 128.

24. Do the worksheet 4-6 according to the directions attached to it.

25. Tape 4-6A.

26. Do table (exercises 5-10) on page 129 except for the base 12 column.

27. Do exercises 11-22 and 24 and 25 on page 129. Correct and hand in.

28. If you are a B average or better in math, do exercises 27-32 on 129. Correct and hand in.

29. Listen to tape 4-6A. The answers to worksheets are on this tape.


31. Write the answers to the Chapter test. Correct and hand in.

32. SUPPLEMENTARY EXERCISE. Extra for Experts on 133 and 134.

33. SUPPLEMENTARY EXERCISE. Extra for Experts on 249.

34. Review.

35. Test over Chapter 4.
MATHEMATICS ASSIGNMENTS

UNIT FIVE

Name

1. Tape 5-1.

2. Do oral exercises 7-16 on page 142 and written exercises 1-32 on pages 143 and 144.

3. Tape 5-2.

4. Practice sheet of subtraction and proof.


6. Tape 5-3.

7. 2 extra sheets of multiplication involving zero. Written exercises 1-26 on page 154.

8. Tape 5-3A.

9. 3 worksheets to accompany 5-3A.

10. Tape 5-004, division. (Check all division work by multiplication.)

11. 2 sheets of division problems. Use the scaffolding method.

12. Problems 1-10 on page 157, problems 1-14 on page 158.

13. Tape 5-4, division.

14. 2 worksheets of division problems, use the scaffolding method.


16. Printed sheet of verbal problems using the four fundamental operations.

17. Tape 5-5, speed drill.

18. Tape 5-6, speed drill.

19. Write answers to the Chapter test.
21. Supplementary exercises on the Trachtenberg system.
22. Cumulative review in class.
23. Review Chapters 4 and 5.
24. Test over Chapters 4 and 5.
MATHEMATICS ASSIGNMENTS

UNIT SEVEN

Name

1. Tape 7-1.

2. Write the oral exercises on page 215.

3. Do all written exercises on 215 and 216.

4. Tape 7-2.

5. Write the oral exercises on page 220.

6. Written exercises 1-14 on page 220.

7. Do the odd-numbered exercises 15-29 on page 221.

8. Tape 7-3.

9. Fill in the divisibility table for 2, 3, 4, 5, 6, 9 and 10.

10. Exercises 7-16 on page 226.

11. Tape 7-3A.

12. Complete the divisibility table for 7 and 11.

13. Tape 7-5.


15. Disregard the instructions in the textbook—Write the prime factorizations for problems 1-12 on page 235. Put them in exponent notation.

16. Tape 7-6.

17. Do not use the directions in the text. Write out the factors of each number. Then find the largest number in the intersection of the sets. Show your work. Oral exercises 1-12 on page 237.

18. Use the sets of prime factors for each numeral to find the intersection and the greatest common factor. Written exercises 1-18 on pages 238 and 239.
20. Problems 1-8 at the top of page 241.
22. Oral exercises 1-18 on page 243. Written exercises 1-19 on 244.
24. Chapter test in text. Chapter review in text. TEST.
MATHEMATICS ASSIGNMENTS
UNIT TEN

 Name

 1. Study pages 326-327 in the text.
 2. Write the answers to 1-8 on page 326. (Answers are on the tape.)
 3. Tape 10-1. KEEP YOUR BOOK OPEN AS YOU LISTEN!
 5. Written exercises on page 330. Check and hand in.
 6. Tape 10-2. PARTICIPATE! DO THE PROBLEMS AS DIRECTED!
 8. Solve oral exercises on pages 334-335.
 9. Do the even-numbered written exercises on pages 335-336.
10. Tape 10-3.
12. Solve the oral exercises on 340.
13. Written exercises on pages 340 and 341.
15. Tape 10-4.
17. Worksheet of fraction problems.
19. Written exercises on 344 and 345.
20. Tape 10-5.
21. Study pages 345-347.
23. Even-numbered written exercises on 348 and 349, 1-42.


29. All written exercises 29-36 on page 354.

30. Tape 10-007.

31. Drill sheets which accompany 10-007.

32. Oral exercises 1-20 and 2132 on 357 and 358. Use the complex fraction system.

33. Seminar.

35. Tape 10-7.

36. Written exercises on 358 and 359. Follow the directions as given on the tape.

37. Tape 10-008.

38. Worksheet which accompanies 10-008.


40. Worksheet 10-8.

41. Oral exercises 1-30 on page 363.

42. Written exercises 1-32 on 363 and 364.

43. Supplementary exercises as needed.


45. Chapter test on page 366.

46. Oral review.

47. Test over Chapter 10.
Skip Chapter 6 for now and we will discuss Chapter 7, Number Theory. There are some very interesting ideas in number theory, and we will start with the division algorithm and apply it. Please look at the printed sheet.

If we are to divide 25 boys into baseball teams, we could write the sentence, 25 is equal to 9 times q plus r, where r has to be less than 9. Filling in the blank in the second row then, 25 is equal to 9 times 2 plus 7. If we have 33 boys, we have the sentence, 33 is equal to 9 times 3 plus 6. We have 3 baseball teams and 6 players left over. If we have 36 boys, 36 is equal to 9 times 4 plus zero. This is a special case. Whenever the remainder r turns out to be zero, we have a special situation.

Consider the basketball teams; this is boys’ basketball. Twenty-four is equal to 5 times what number. Yes, we will have 4 teams, 5 times 4 plus 4. The remainder must be less than (pause) 5. Yes. The remainder must be less than 5 because we are using 5 as our group size, our divisor. OK, we have 18 boys, 18 is equal to 5 times ___ plus how many? I hope you filled in each blank with a 3. Three teams plus a remainder of 3. And if we have 10 boys, this is equal to 5 times 2 plus zero. Again, a special case. We are using the formula which is given in the upper right hand corner, a, the amount is equal to b, the divisor, times q, the partial quotient, plus the remainder. This is our check process for division; we take the divisor times the quotient and add the remainder and we get the original amount which was the dividend.

Moving down to the middle of the page where we start with 16. Is 16 equal to b times 8 plus zero? What numeral will take the place of b? Sixteen is equal to some whole number times 8 plus zero. Yes. I hope you filled it in with 2. In the next example, we have 25 is equal to b times 5 plus zero (pause) and I hope you filled the blank in with 5. Thirty-six is equal to b times 4 plus zero. Thirty-six is equal to 9 times 4 plus zero. If a is equal to 3 times 6 plus 2, then the original amount must have been 20. Agreed? And if 17 is equal to 3 times 5 plus a remainder, the remainder must have been 2. Agreed? And finally, if 21 is equal to 4 times q plus the remainder and the remainder has to be less than 4, then 21 is equal to 5 times 4 plus 1.

Starting with 16 again, since 16 is equal to 2 times 8 and the remainder is zero, we can say that 16 is a multiple of 8. Sixteen is also a multiple of 2. Twenty-five is a multiple of 5 since the remainder was zero. Thirty six is a multiple of 9 and 36 is a multiple of 4 since the
remainders are zero. Is 20 a multiple of 3? No, 20 is not a multiple of 3 because there is no whole number that you can take times 3 and arrive at 20. We have to use 3 times 6 and then add a remainder of 2.

Answer the 4 true-false questions. Turn off the tape reader while you do this, then we will correct them.

Are you ready?

Number 1 is true. Number 2 is true. Number 3 is false, and number 4 is true.

What whole number can you take times 11 to get 11? Yes, one.

Try the yes-no section. Turn off the tape reader while you do these. It will take you a little more time to do the division.

Number 1, is 98 a multiple of 12? You know if you learned the 12 tables that eight times 12 is 96 so the answer to this question is no. Ninety-eight is not a multiple. Is 56 a multiple of 7? Yes, 7 times 8 is 56. Is 144 a multiple of 8? Yes, if you divide 144 by 8 you arrive at 18 with a remainder of zero. Right? The last one, is 230 a multiple of 9? No, when you divide 230 by 9 you arrived at a quotient of 25 with a remainder of 5. Since the remainder was not zero, 230 is not a multiple of 9.

If we were to consider all the multiples of 8, we would have to say that 1, 2, 4, and 8 are all multiples of 8. Consider the multiples of 12: 1, 2, 3, 6, and 12 are all multiples of 12. Go to the bottom of the worksheet and write all the multiples of 36. Stop the tape reader while you do this and correct it when you finish.

Have you listed 1, 2, 3, 4, 6, 9, 12, 18, and 36? They are all multiples of 36. Stop the tape reader while you write the multiples of 50. Did you write 1, 2, 5, 10, 25, and 50?

Please turn to page 215 in your textbook. You will see in the oral exercises that you are asked to fill in the missing part. I am sure that you will not have any difficulty doing this. Beginning with number 11, you are asked to fill in each blank with either is or is not. Because 39 is equal to 3 times 13, 39 is a multiple of 3.

Solve the oral exercises and the written exercises according to the assignment sheet. Remember one number is a multiple of another, if you can divide the large one by the small one and the remainder is zero.

Thank you.
Worksheet for the tape: 7-1

**Baseball teams**

25 = (9 x q) + r, r < 9  
25 = (9 x ____) + ___  
33 = (9 x ____) + ___, r < 9  
36 = (9 x ____) + ___, r < 9  

**Basketball teams**

24 = (5 x ___) = ___, r < ___  
18 = (5 x ___) + ___, r < 5  
10 = (5 x ___) + ___, r < 5  

16 = (b x 8) + 0  
25 = (b x 5) + 0  
36 = (b x 4) + 0  
16 = (___ x 8) + 0  
25 = (0 x 5) + 0  
36 = (___ x 4) + 0  
If a = (3 x 6) + 2  
17 = (3 x 5) + r  
21 = (4 x q) + r, r < q  
____ = (3 x 6) + 2  
17 = (3 x 5) + ___  
21 = (4 x ___) + ___

T F 1. 36 is a multiple of 4.  
T F 2. 18 is a multiple of 9.  
T F 3. 20 is a multiple of 6.  
T F 4. 11 is a multiple of 11.

Yes No 1. Is 98 a multiple of 12?  
Yes No 2. Is 56 a multiple of 7?  
Yes No 3. Is 144 a multiple of 8?  
Yes No 4. Is 230 a multiple of 9?

Write all the factors of 36:

Write all the factors of 50:
Yesterday we learned that one number is a multiple of another when we can divide and the remainder is zero. Lesson for Chapter 7, Section 2, entitled, Prime Numbers, page 216 in the textbook.

Yesterday we learned that one number is a multiple of another when we can divide and the remainder is zero. Question? Is 7 a multiple of 3? Is 18 a multiple of 3? Is 96 a multiple of 7? Repeat the questions if you need to.

First question. Is 7 a multiple of 3? No. Is 18 a multiple of 3? Yes. Eighteen divided by 3 is equal to 6 and the remainder is zero. The last question, is 96 a multiple of 7? I hope you divided 96 by 7. The quotient is 13 and the remainder was 5. So 96 is not a multiple of 7.

Today we are going to express the same concepts using the word, divisible. Is concept a new word? Idea and concept have about the same meaning. The statement that 8 is a multiple of 2 may be restated, 8 is divisible by 2. "Divisible by" means the remainder is zero. If 15 is divisible by 3, then when I divide it by 3, the quotient is a whole number and the remainder is zero.

"Is a divisor of" or "is a factor of" mean the same thing. If a multiple of 8 is a multiple of 2, this means 8 is divisible by 2.

Every number has some factors. The number 1 has itself as a factor. One times one. Monotonous, isn't it? The number 2 has itself and one as factors. Two times one. What are the factors of 8? If we simply list all the numbers which are factors of 8, we would list 1, 2, 4, and 8.

List the set of factors of 24. Stop the tape reader while you do this.

I hope you have written 1, 2, 3, 4, 6, 8, 12, and 24. Twenty-four is divisible by each of those numbers and 24 is a multiple of each of those numbers.

The only set of factors for a number is itself and one. If the only set of factors is the number itself times one, as in the case of 11, 11 times 1, then that number is a prime number. Prime numbers by definition have to be greater than one. Prime numbers are greater than one and have as factors only themselves and one.

What is the set of factors of 23? Check the numbers smaller than 23. Will 2 divide into 23? Is 23 divisible by 3? Is 4 a factor of 23? Is 5 a factor of 23? Did you find that 23 is divisible only by itself and one? Since 23 has no other factors, it is a prime number. Remember we have
Defined prime numbers to be greater than one and they have as factors only themselves and one. All other whole numbers greater than one which are not prime are composite numbers. Other whole numbers which are not prime are called composite numbers.

Will composite numbers have other factors beside themselves and one?

What is an even number? Is an even number always divisible by 2? What do we call the numbers which are not divisible by 2? Yes, if a number is divisible by 2, it is even, and all the others are odd.

Please refer to the chart entitled, "Finding Prime Numbers", which you were given today and follow the directions on the tape.

We are going to construct a sieve to find the prime numbers. Do you know what a sieve is? Surely the girls have used a sieve in the kitchen. If you panned for gold on your trip out West, you used a crude sieve which let the sand and water run out and kept the gold in. We are going to build a sieve which will keep the prime numbers in and drop all the other numbers out.

We cross out 1, since 1 is not prime. Prime are defined to be greater than 1. Two has as its factors itself and one. Two must be prime, we leave it. Three has as its factors, 3 and 1. Three must be a prime number. What are the factors of 4?

Since 4 can be written as 2 times 2 or 4 times 1, it is not prime as it has the factor 2, besides itself and 1. We cross out 4. What are the factors of 5? Is 5 prime? Six can be written as 6 times 1 or 3 times 2. Is 6 prime or composite? You are right, it is composite and we cross it out. This is going to be kind of slow, isn't it?

Do you have any quick ideas for dropping a lot of numbers through this sieve?

Hey, I've got a good idea. How about crossing out all the even numbers except 2. Then all the numbers that are left will be prime. How do you like that?

Are all of the odd numbers prime? Are all of the even numbers greater than 2 composite numbers? Should they be crossed out? Yes, we can blank out whole rows of them, can't we? We can blank out all the rows which are even numbers.

Are all the odd numbers prime? Three, 5, 7, 9. Ouch! Nine is 3 times 3. Nine is composite so you will have to cross out 9. Well, my idea got rid of a lot of composite numbers, didn't it?

Since 3 was prime but 3 times 3 was composite, will 3 times 4 be composite? How about 3 times 5? Let's skip count by 3's. Do you know what skip count means? If we skip count by 5, we go 5, 10, 15, 20, 25,
30. OK? Let's skip count by 3's. (Pause) Will every number larger than 3 be crossed out? Six, 9, 12, 15, 18, 21, 24. (Pause) Are all of these numbers composites? Yes, every number greater than 3 is a composite, because it has 3 as a factor. Now, do you know how to find the primes?

Go through and cross out all of the numbers on this page which are divisible by 3 except for the number 3 itself. Stop the tape reader while you do this.

OK? Five is a prime number. Can we use 5 to get rid of more composite numbers? Have you crossed out all of the multiples of 5? Why do I think you should do that so quickly.

What is the first multiple of 6 which comes after 6? Twelve, that's already crossed out. How about 18? That's already crossed out. How about 24? Already gone? Are all the multiples of 6 already cross out? How about that. That's kind of nice. Why are they all crossed out already?

How about 7? Is 7 a prime number. Yes. Do you have every multiple of 7 crossed out? Let's skip count. Stop the tape reader and cross out all the multiples of 7 which are larger than 7 by skip counting. Seven, 14, 21, etc.

You must have gotten at least one new one out that time and that would be 49.

How about the multiples of 8? Cross them out. They're already crossed out. Do you know why they are already crossed out?

OK. Let's try the multiples of 9. They are already through the sieve.

How about all the numbers that 10 goes into? They are all crossed out already.

This is working real well. Is 11 a prime number or is it a composite number. You're right, it is prime. Let's cross out all factors of 11: 22, 33, 44, 55, 66. They were already gone, weren't they?

How about 12? It's already gone. How about 13? Is it prime? OK, let's cross out the factors of 13. I'm sorry, let's cross out the multiples of 13. Twenty-six, 39, 52, 65, 78; you are right, they were already gone. Fourteen is out, 15 is out, 16 is out. Is 17 a prime number? Yes, 17 times 1, the only factor is 17. Thirty-four, 51 already gone? Sixty-eight? Let's look at the fellows that are left.

Are all of the numbers which have not been crossed out prime? Are you sure? You are absolutely sure? You should have the set of primes which are smaller than 120 on this sheet.
Could we build a bigger sieve? The Greek scholar, Eratosthenes, developed this sieve about 2200 years ago. They were thinking even then.

What is the largest prime we need to throw out all the composite numbers under 100? What is the largest prime we need to use to skip count to eliminate all of the composite numbers smaller than 40?

Try to make a general statement about the size of the largest prime that we need to use to test any set. This is an easy lesson. Have fun with it.

Thank you.
Worksheet for the tape: 7-2

Finding Prime Numbers

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</table>
You have finished the first chapter using Audio-Tutorial instruction. Do you have any suggestions for improving this system? Please express your feelings and suggestions below:
Questionnaire at the completion of 3 chapters

We have now completed 3 chapters using the Audio-Tutorial method. Please express your present feelings about this system. Please offer any suggestions which you think would improve this way of teaching. Would you like to return to the ordinary classroom method for math? Thank you.
AUDIO-TUTORIAL QUESTIONNAIRE

January 15, 1969

You have been part of an experiment in the teaching of seventh grade mathematics by the audio-tutorial approach. In order to make improvements in the course, we ask that you give your impression of the course. Please circle the choice which is closest to your opinion.

Tapes:
1. On the tape, was the information presented:
   A. Too quickly  B. About right  C. Too slowly

2. Did the taped instructions prepare you to study the material properly?
   A. Usually  B. Sometimes  C. Never

3. How many times did you replay a whole tape?
   A. Never  B. Once  C. Twice  D. Three times  E. More than 3 times

4. Did you replay a part of a tape:
   A. Often  B. Seldom  C. Never

5. Compared to the beginning of the course, how much did you replay parts of the tapes toward the end of the semester?
   A. More often  B. About the same  C. Less often

6. Did the explanations on the tape help you understand the textbook material clearly?
   A. Always  B. Usually  C. Seldom

7. Do you know whose voice is on the tapes?
   A. Yes  B. No

8. Did you have an opportunity to ask questions over areas which you did not understand?
   A. Yes  B. No
9. What one improvement would you suggest to increase the value of the tapes?

Chapter outlines:
1. Could you work effectively without the chapter assignment sheet?
   A. Yes        B. No
2. Would you like to have some review questions included on this sheet so you would know what materials are most important?
   A. Yes        B. No
3. What improvements would you suggest?

Answer books:
1. Do you prefer to check your own work rather than doing it with the teacher reading the answers to you?
   A. Yes        B. No
2. Do you feel that other students used the answer books unfairly?
   A. Definitely know some have copied from answer books
   B. Do not know of anyone who used the books unfairly

Review:
1. Did you think the oral class review at the end of each chapter was helpful?
   A. Yes        B. No
2. Did you have an opportunity to ask questions over areas which you did not understand?
   A. Yes        B. No
3. Would you rather have the review sessions include only a group of 8-10 students rather than the entire class?
   A. Yes        B. No

Seminar:
1. Do you think the seminar sessions were worthwhile? A. Yes B. No
2. Would you prefer seminar sessions in every chapter? A. Yes B. No
Overlays:
1. Were the overlays clear enough to be helpful to you in your study of the material?  
   A. Yes  B. No
2. Do you feel that the overlays covered the material the teacher usually writes on the blackboard?  A. Yes  B. No

Listening Centers:
1. Do you prefer to use a tape alone or on a listening center?  
   A. Alone  B. Listening center  C. No preference
2. Please express your opinion about the use of listening centers

General:
1. What is your opinion of the audio-tutorial method for teaching math?

2. Do you prefer this organization of instructional material over the usual-in-class method? Why or why not?

3. Do you think you put forth more effort in audio-tutorial math than in:
   A. 6th grade math? Yes  No  Why?
   B. 7th grade science? Yes  No  Why?

4. After hearing Miss Hall's voice on the tape, did you feel she was the teacher?

5. Do you feel that you know the members and teacher in this class as well as in your other classes? Please comment.

6. Were your test grades equal to your effort in audio-tutorial math?

7. Do you consider this first semester of 7th grade math a success?

8. Make any other comments about this semester on the back of this sheet. Thank you.
Appendix D: Expenses for Audio-Tutorial Development
Costs incurred by the Boone Community School District in the implementation of the audio-tutorial approach

**Equipment and Materials**

<table>
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<tr>
<th>Item</th>
<th>Cost</th>
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<td>Dictaphone belts</td>
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<tr>
<td>Hardware</td>
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<td>Tapes and reels</td>
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<td>Listening centers</td>
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<td>Programmed practice books</td>
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<tr>
<td>California Achievement Tests (Forms W and X)</td>
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</tbody>
</table>

Total monies spent by Boone Schools: $2,471.26

**Federal funds used in the development of the project**

**Elementary-Secondary Education Act**

- Development of teaching materials
  - Miss Hall, 200 hours @ $6.00: $1,200.00
  - Mr. Friedrich, 80 hours @ $5.00: 400.00
  - Total: $1,600.00

**Elementary-Secondary Education Act Work-Study Project**

- Room renovation supervision, Mr. Thompson: $660.00
- Materials for carrels, shelves, bulletin board: 232.65
- Student labor in room renovation: 345.00
- Student assistance making tapes and overlays: 180.00
  - Total: $1,417.65

**National Youth Corps**

- Student secretary, 10 weeks in the summer: $595.00

Total Federal monies: $3,612.65

Total cost of project: $6,083.91
Appendix E: Audio-Tutorial Laboratory
Figure 1. Audio-tutorial laboratory in the Boone Junior High School
16 pigeon compartments

Teacher's station

36 pigeon compartments for assignment sheets, tapes and supplementary lessons. Storage located below compartment area.

x = Student station with tape reader
O = Listening center
s = Student seating

Storage