THE UNIVERSITY OF ALBERTA

THE EFFECTS OF SELECTED PRESENTATION VARIABLES ON LEARNING IN A MEDIATED TUTORIAL PROGRAM IN NURSING EDUCATION

by

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A THESIS

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ABSTRACT

In January, 1971, the following experiment was conducted among first year nursing students at the Royal Alexandra Hospital School of Nursing in Edmonton, Alberta.

A program on the anatomy of the ear had been developed for the experiment. The program consisted of labelled slides with verbal accompaniment. Students thought out responses for questions in the program and then had responses confirmed in a subsequent program frame. Each program frame consisted of a slide with verbal accompaniment.

This program was designed for the purpose of statistically analyzing four different modes of instruction relating to pacing and verbal presentation variables. The four experimental groups, A, B, C, and D, with 19, 19, 19, and 17 students respectively, received instruction in the following manner, slides being a constant. The first two groups were media- or group-paced. They differed in that Group A received verbal instructions through a tape recording. Group B received identical verbal instructions

through a printed booklet.

The last two groups were self-paced and differed in the same manner as that just described. The groups were thus termed, respectively, audio-verbal, media-paced; printed-verbal, media-paced; audioverbal, self-paced; and printed-verbal, self-paced.

Students were given the same test instrument as pre-test, post-test, and retention test, but did not receive knowledge of test results until after the experiment. The pre-test showed no significant difference among the groups. Analysis of variance on post-test and retention test scores also showed no significant difference in achievement. Results of a fifth group which received instruction in the usual manner using a lecture and text-book reading approach were also examined as a matter of local interest.

Media-paced groups were allowed 38 minutes to complete the learning program. Self-paced groups averaged longer. The printed-verbal, self-paced group took 53.12 minutes. The audio-verbal, self-paced group took 60.12 minutes. Because there was no variance in the average time of the media-paced groups, analysis of variance to discover whether these differences were statistically significant was not possible.

Several conclusions were suggested by the results of this experiment. It would seem that with mature learners similar to a nursing class using programs similar to the one in this experiment, that media-pacing can result in some time savings over a self-pacing presentation mode. Also it would seem that a printed-verbal, self-pacing presentation mode offers some savings in average time spent by learners over an audio-verbal, self-pacing presentation with no loss in achievement, other factors being equal. A further conclusion suggested by the experiment is that none of the four approaches provide any significant learning advantages over any of the other presentation modes.

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Chapter I

INTRODUCTION

This study involved the preparation of an illustrated programmed unit on the anatomy of the ear, based on carefully developed behavioral objectives. Various treatment modes were devised using this program and presented to groups randomly selected from a first year class of nursing students. An analysis was made of the effects on learning of each treatment mode. Measurements were also included of the average time necessary for experimental groups to complete each of the presentation modes.

The program as developed, involved use of slides as a constant in presenting visual information. The variables investigated were a verbal presentation variable and a pacing variable. Verbal instructions were presented audibly to half the treatment groups and in printed form to the other half. Half the groups had their pacing pre-determined; the other half proceeded in a self-paced manner.

Random sampling was used to select students for different treatment modes from first year nursing students at the Royal Alexandra Hospital in Edmonton, Alberta. Four main experimental groups were used. As mentioned all treatment groups had slides in common and varied in the following manner: Group A was presented learning materials in a media-paced, audio-verbal mode; Group B media-paced, printed verbal; Group C self-paced, audio-verbal, and Group D a self-paced, printed-verbal mode. A fifth group was compared as well. This group was instructed normally. Since it is difficult to delineate what occurred in the normal group, as opposed to the specified characteristics of the programmed events, any statistical comparison between the normal group and the programmed group is questionable. A comparison does, however, serve to help validate the programmed material, for all instruction was carried out with the same basic goals. Had the programmed groups been substantially poorer than the normal group then the programmed materials would have been questionable.

The same testing instrument was used for the pre-test, post-test, and retention test. The pre-test was administered to serve as a base for analysis of covariance. It was also used to check that random selection had provided for groups having similar prior knowledge of the learning materials.

A questionnaire was administered with the retention test. Attitudes and opinions of students as revealed on this questionnaire relating to varying instructional modes could be valuable to some educational planners.

THE PROBLEM

As instructors face a variety of students in a variety of instructional settings, it seems apparent that many instructors will wish to develop individual multi-media programs to meet local problems. In considering the development of programs these instructors will ask questions concerning pacing and modes of presenting verbal information. If these instructors have considered such popular approaches as the audio-tutorial method publicized by Postlethwaite (1970), they will probably be influenced to use individual pacing and audible presentation of verbal information.

Opposition, however, does exist for both of these approaches as major techniques for presenting programs, unless, of course, definite procedural advantages were to exist for them. Severin (1967) says of individual pacing that it may sometimes be a means of producing habits in learners detrimental to learning achievement. Hartman (1961) feels that for mature learners printed-verbal instructions are preferrable to audible-verbal instructions.

This leads to the specific problems as they exist for this study. These problems might be briefly formulated as follows:

1. Does presenting a learning program using taped-verbal instructions present advantages for average learning achievement over a program using printed-verbal instructions? Also does either presentation offer time advantages for learners?

2. In presenting a program to learners does individual pacing produce greater average levels of achievement than media pacing where students in a group are given the same amount of time? Are average time advantages apparent for either mode of presentation, media-paced or individually-paced?

3. Are there any significant interaction effects on average learning achievement of groups involved with the above mentioned pacing and verbal presentation variables? Further, are there any interaction effects on time required for completion of the programs?

THE PURPOSE

In an experimental sense the purpose of the study was to collect data related to the problems as delineated earlier.

The first purpose, experimentally, was to discover whether groups using self-pacing achieved significantly different learning scores from those using media-pacing. Also, the experiment was designed to see whether one or the other of these approaches required more time.

A second purpose was to discover whether any significant differences in learning achievement occurred due to an audible-verbal presentation as compared with a printed-verbal presentation.

Average time for each treatment was also recorded. In analyzing data collected relating to the above variables, it was determined that data should be first analyzed in terms of "among groups" hypotheses. Such hypotheses would compare average scores of all groups: audio-verbal, media-paced; printed-verbal, media-paced; audio-verbal, self-paced; and printed-verbal, self-paced.

If no significant differences occurred with among group hypotheses on statistical analysis of variance it would be unnecessary to carry such statical analysis further.

As well as hypotheses relating to variables already discussed, hypotheses are stated relating these presentations to a "normal group". This latter group received instruction through a textbook reading and lecture method. Data comparing this normal group with the groups receiving programmed instruction were included primarily as a matter of local interest as well as for the purpose of determining whether or not the programmed presentations were as effective in instruction as the method normally used in the Royal Alexandra Hospital School of Nursing.

For convenience of reference the four experimental groups will be referred to as groups A, B, C and D. The normal group will be referred to as group E. The letters A, B, C and D will refer to the following groups respectively: audio-verbal, media-paced; printed-verbal, media-paced; audio-verbal, self-paced, and printed-verbal, self-paced.

Following are the statistical hypotheses formulated in order to carry out the experimental purposes of this study.

Hypothesis I

There is no significant difference among the four experimental groups (A, B, C and D) on

a. pre-test performance

b. post-test performance

c. retention test performance

Hypothesis II

There is no significant difference among the four experimental groups in the time taken to complete the program.

Hypotheses III and IV are similar to I and II with the addition of the normal group.

Hypothesis III

There is no significant difference among the five groups (A, B, C, D and E) on

a. pre-test performance

b. post-test performance

c. retention test performance

Hypothesis IV

There is no significant difference among the five groups in the time taken to complete the program.

Should significant differences have occurred in analysis of the above among group hypotheses, then further between group hypotheses would have been necessary in order to pinpoint the differences more precisely.

One would particularly wish to compare self-paced groups (C and D) with media-paced groups (A and B) and the printed-verbal groups (B and D) with the audio-verbal groups (A and C). Such a comparison is important since pacing and verbal presentation are the independent variables in the experiment.

Hypotheses which would follow a finding of significant difference on among groups hypotheses are as follows.

Hypothesis V

There is no significant difference between

a. groups A and C and groups B and D

b. groups A and B and groups C and D

on

i. pre-test performance

ii. post-test performance

iii. retention test performance

Hypothesis VI

There is no significant difference due to interaction effects for the above stated groups on

a. pre-test perfromance

b. post-test performance

c. retention test performance

Hypothesis VII

There will be no significant difference in time taken for

a. groups A and C compared with groups B and D

b. groups A and B compared with groups C and D

c. any combination of the above groups due to interaction effects.

When the normal treatment group is included in the analysis a further set of between group hypotheses becomes necessary.

Hypothesis VIII

There is no significant difference between any of the five groups on

a. pre-test performance

b. post-test performance

c. retention test performance

Hypothesis IX

There is no significant difference between any of the five experimental groups in time taken to complete the learning materials.

NEED FOR THE STUDY

Several reasons exist for examining the problems mentioned above and formulated in the hypotheses. Many of these reasons are discussed more fully in the review of the literature. Brief discussion follows.

Heidgerken (1948) called for many more carefully designed and statistically analyzed studies in the area of audiovisual education in the field of nursing. Since her study in 1948 the reference books show that few such studies have taken place.

Mary Seedor (1963) after experimenting with a programmed learning package on the subject of asepsis in a nurse's training program wrote:

> Programmed instruction is here; it can teach. Instructors, must, therefore, try to understand it, work with it, and evaluate it.
> Seedor (1963:120)

Geis and Anderson (1963) suggest a further reason for experimenting with programmed information in the area of medical education. They write:

> The problem of correlating nursing theory and practice becomes acute in some areas. A year or more may go by, for example, between the time the student learns a particular technique in class and practices it on a patient. . . . Programs in

> these difficult areas can be kept constantly available and thus provide a new flexibility in nursing education. Geis and Anderson (1963:592)

If programs are to be developed and made accessible then information should be available on the best and most efficient sorts of programs to utilize.

As Seedor (1963) has suggested, learning programs are here. They are also effective in producing learning, as Schramm indicates when he writes:

> Do students learn from programmed instruction? The research leaves us in no doubt of this. They do, indeed learn. They learn from linear programs, from branching programs built on the Skinnerian model, from scrambled books of the Crowder type, from Pressey review tests with immediate knowledge of results, from programs on machines, or programs in texts. Many kinds of students learn - college, high school, secondary, skilled labor, clerical employees, military, deaf, retarded, imprisoned, every kind of student that programs have been tried on. Schramm (1964:3-4)

In considering an audiovisual experiment utilizing programmed instruction one faces a great number of instruments and a great number of techniques for using these instruments in presenting a learning program. Since opposing claims often arise favoring one or another of the many presentation techniques it seemed valuable to examine some of these techniques to determine whether or not learners do achieve differently as a result of different presentations of programs containing the same information. It also seemed valuable to determine whether or not time savings might result from certain presentation techniques as opposed to others.

Two areas of investigation immediately presented themselves. One area was suggested by Carr (1960) when he wrote:

> Two important ways of presenting a program exist. The first way might be called "learner-paced" in that the device waits upon the learner to respond before it reacts...The second way of presenting the program might be called "machine-paced" in that a given problem is presented for a period of time and then the machine reacts whether or not the learner has responded to the problem...One research problem which might well receive immediate attention is the relative efficiency of group-paced versus learner-paced devices. Carr (1960:561)

This problem has not been solved in the decade or more since Carr wrote. The audiotutorial approach as supported by Postlethwaite, Novak and Murray (1969) and practiced in nursing, Deegan, Deiter, and Voelker (1968) has as one of its components self-pacing by the student. However, Gropper, (1965) is a researcher who feels that individual pacing may be inefficient in use of time and may even lead to producing bad learning habits in students.

These factors led to the conclusion that more research should be done with programs which examine the effects on learning of individual pacing versus machine or media pacing.

Another facet of the audio-tutorial approach is its use of taped, verbal lecture material. Postlethwaite, Novak, and Murray (1969), Deegan, Deiter, and Voelker (1968), and Watson (1968) support the use of such audio instructions in a programmed presentation. On the other hand Hartman (1961b) feels that printed, verbal instructions have benefits over audible, verbal ones.

Such disagreement again leads to a need for study and analysis of the use of audible, verbal instructions as opposed to printed, verbal instructions.

Literature on program design indicates that pictures and illustrations provide benefits for learning over a straight verbal text Pipe (1966), and Lumsdaine (1965). Thus plans were laid for an illustrated program.

It was also decided to produce the program locally. One reason for this was that commercial sources, present and future, will probably be unable to provide programs of sufficient topic variety to meet requirements of individual instructors. Producing these materials locally was meant in part to reveal that adequate tailor-made programs can be produced with a minimum of technical materials. It was also meant to emphasize the potential for producing such materials.

These materials were also designed to be part of a specific curriculum, namely the anatomy curriculum in nursing education. This last characteristic was meant to answer, in part, criticism such as that levelled by Travers, who writes about problems with audiovisual research stating that "Visual and auditory aids to learning have not generally been introduced as a part of a systematic learning program." Travers (1964:144)

Conway (1967) has also criticized a number of experiments in audiovisual instruction in that

> experimental settings do not even attempt to provide a simple model of the typical media or learning situation. It seems undeniable that extrapolation beyond the results of any given study to actual conditions is therefore unwarranted. Conway (1967:375)

This experiment does attempt to provide a simple model of the typical media or learning situation and draws its conclusions from students learning in such a setting. Thus it does fill a need. Other experimenters who have also followed a similar practice are Chance (1961), Perlberg and Resh (1967) and LaFollette (1969).

Another possible need for this study lies in the fact that, though programmed learning has acknowledged value, there is still limited use of this means of instruction in most areas of educational activity. Studies in individual settings may help to involve local instructors in use of this medium and still be constructed in a manner which will add to general educational knowledge. Particularly if a program of study or even part of a program can be left with instructors for future use after an experiment is there the possibility of affecting educational practice by enabling instructors to continue use of such materials. This idea is confirmed by Popham who writes concerning curriculum reform in the United States:

> An examination of the curriculum reform movement in this country during the 1960's reveals that without exception those curriculum projects which had the most significant effects upon educational practice produced curriculum materials to implement their scheme.
> Popham (1969:319)

In the present study particular attention was given to providing materials that the institution might use after the experiment was over. It was felt that such a move might encourage instructors to move from the theory of the experimental procedures to actual incorporation of these procedures into normal instruction.

CONSTRAINTS

There were several constraints or limiting factors affecting this experiment. Generally these constraints related to the limited population studied, the limited time the experiment ran, and the limited subject matter studied. More specific constraints, however, can be itemized. The first specific constraint relates to the sex of the subjects. One might regard a class of nurses as a fairly representative group of academic post-secondary learners, yet the fact that this class was wholly female may present some learning differences when compared with a mixed male and female population or a totally male population.

A further limiting factor lay in the brevity of the program which left a limited amount of material to draw questions from for testing purposes. The test was thus fairly brief. A longer program, however, would have added problems not manageable under conditions which existed.

The fact that the test was brief and that the program was intended to produce high levels of performance made it impossible to use normal reliability measures. Discussion of this point occurs in Chapter III.

A further limitation existed due to the fact that only one unit of study, one on the anatomy of the ear, was used in this experiment. Had several different units of study been available using similar preparation, presentation and testing techniques, rather than just the unit on the ear, wider generalizability of the experimental results might have been achieved. This, however, had to be left for other experimenters due to time and cost factors.

For the four main experimental groups, one must be aware that this was a novel learning environment. This may have influenced results when comparisons were made with the normal group. Further, the individually-paced groups had limited experience with the equipment. This may have had some detrimental effects on learning, although a questionnaire given after the experiment did not record any comments by students on the detrimental effects of inexperience.

The limited number of programs meant that not all learners could receive their treatments at one time. Some participated before 3:00 p.m. in the afternoon and others between 3:30 and 5:00 p.m. Also some participated on a Monday and others on a Tuesday. Attempts were made to balance individually-paced groups so that as many as possible participated on the same day as the media-paced groups, but some effects on learning may still have existed. It is hoped that such effects were minimal.

The above seem to be the major constraints in this experiment. Though they do limit the degree of generalizability of the results, none of these limiting factors should invalidate the experiment. Only further similar experiments will be able to reveal with more clarity the effects of the above constraints on experimental results.

ORGANIZATION OF THE STUDY

Reporting of the experiment is organized in five chapters. The first of these chapters, the Introduction has just been completed. The second chapter is a review of literature related to the problems considered in this experiment. The third chapter is titled "Method" and discusses physical facilities, stimulus materials, and experimental procedures adopted for this experiment. The fourth chapter presents the results of the data with a discussion of this analysis. The last chapter is a summary of experimental procedures and statistical results. It also presents conclusions and recommendations related to the important variables of this experiment.

DEFINITIONS

Due to the variety of modes, methods, and apparatus of modern instructional activity confusion often arises in terminology. The terms listed below will be used in this study according to the following definitions:

Audiovisual media

Erickson (1968:30) suggests that a widely accepted meaning of this term "refers to materials of instruction with the exception of printed ones," and is "generally assumed to include both materials and equipment."

The investigator does realize, however, that a widespread move is in progress to adopt a systematic approach to education in which all techniques, tools and personnel are regarded as part of a whole and where each part is fitted into an ongoing process in the best manner possible; and that such a move may well lessen the importance of the term audiovisual media. This will become particularly true as profusely illustrated texts become more common and as print becomes more common on moving films, filmstrips, and slides.

Behavioral Objectives

This term refers to a statement or statements formulated by an instructor for students in which the instructor states what the student should be doing at the completion of a learning period in order to demonstrate that he has reached an acceptable level of learning achievement. Such a statement also refers to the conditions under which the student will be demonstrating this achievement. Mager (1962:43)

Instruments

For the purpose of this study "instrument" will refer to an electronic device with which messages are delivered. It is specifically understood to be "a technological term used whenever audiovisual technology is emphasized. It is also a synonym for hardware." Erickson (1968:31)

Media-pacing

Media-pacing will refer to an experimental condition in this research in which time for study will be controlled by a source external to the learner. The term will be used interchangeably with fixed-pacing.

Programmed Instruction

In considering programmed instruction one faces several possible definitions. Lysaught and Williams (1963) suggest the following guidelines for programs.

1. Assumptions must be clearly stated in writing
2. Objectives should be explicitly stated
3. There should be a logical sequence of small steps
4. There must be active responding by learners
5. Immediate feedback of information must be available to the student responding
6. There should be individual rate of learner progress
7. There should be constant evaluation of the learner

Such a definition of programmed instruction with its several rigid specifications is quite different from the more general one given by Lumsdaine (1961).

> Generically the notion of programmed instruction is perhaps nearly synonymous with that of instructional media. This in general implies the presentation of instructional material to the student in pre-planned, pre-sequenced order. In programmed instruction the sequence is determined or regulated either by the inherent structure of the media, by well defined procedures and constraints in the way they are used, or by the characteristics of mechanical arrangements which are used to present a program of material... Lumsdaine (1961:2)

The program devised for this experiment followed the format suggested by Lysaught and Williams (1963) in steps one through five. Pacing was investigated in the experiment, and thus being a variable was not constantly individualized. The last point, constant evaluation, is more related to prolonged learning through programmed instruction and so was not applicable.

The program developed for this studydid vary in step size from many programs. This was done in order to reduce the number of slides which would have been necessary with shorter steps and also to provide for a greater sense of continuity.

In speaking of frames in the context above, the author is using Skinner's view (1958:970). Skinner suggested that a frame is a limited amount of information available to a student at one point in time.

Self-pacing

Self-pacing will refer in this study to a condition in which students proceed through a given body of stimulus materials at a rate of speed each considers optimal for his or her own learning.

Stimulus materials

Stimulus materials will refer in this study to an "Organized class of events which impinge on an organism's sensory equipment and which experimenters can manipulate and describe..." Audiovisual Communication

Review (1963:74) This "class of events" should be reproducable and designed to produce "a change in the stable relationship between (1) a stimulus that the individual perceives and (2) a response that the organism makes either covertly or overtly." Audiovisual Communication Review (1963:56)

Chapter 2

RELATED LITERATURE

COVERT VERSUS OVERT RESPONDING

This study involves a program of instruction developed for a particular unit in anatomy for first year nursing. In present day instruction one need make no excuses for using a program as opposed to instruction mediated by a live instructor. Schramm's statement, (1964:3-4) mentioned in the introduction, is an indication of the number of groups which have learned through programmed instruction. It is apparent that students do learn through programmed instruction, yet there still remains a great deal to learn about the components which make up a good program. There is also much to learn about how manipulating these components affects student behavior.

Some of the components which have long been regarded as basic parts of programs are short steps, or one bit of information to be learned at one time, responding to questions by students, and correct answers supplied by the program as a reenforcement to the student.

In most programs after a student has progressed through a short step, that is, studied a program frame, he is then asked to respond correctly to a question on that bit of information. Some individuals feel that the student must make an overt response to the question Cummings and Goldstein (1964). This overt response may be speaking a word aloud, writing out a word, underlining the correct choice in a multiple choice list, drawing a picture, or, in short, making a response observable to an onlooker.

In this study, however, a decision was made to use covert responding. It was felt that overt responding would lead to complications in time factors. Also it was felt that writing out answers could have influenced learning and so complicated the other results in the experiment. The following literature seems to show that neither covert nor overt responding possess an inherent advantage over the other with the possible exception that covert responding requires less time.

Carr (1960) reports an unpublished research project carried out by Evans, Glaser and Homme who:

> ...compared the effectiveness of the construction method of responding with no overt responding at all. In this experiment two groups of Ss learned a program entitled 'fundamentals of music'. One group made one or more written responses to each problem, while the other group made no overt responses. Interestingly enough, the group which made no overt responses spent less time in learning and showed slightly higher retention test scores than did the group which responded to each problem.
> Carr (1960:561)

On the other hand Cummings and Goldstein (1964) found better results for the overt responding method. The program they devised was a self-paced program consisting of 119 frames on the topic of the origin, varieties, and diagnosis of myocardial damage. The testing behavior required of students involved recognition and drawing of electrocardiogram tracings. There was an immediate post-test and a ten day delayed retention test. The overt responding group wrote out all their answers. The covert responding group thought out all their answers in the learning phase with no visible record of responses. In Cummings and Goldstein's experiment the overt responding group did significantly better on post-test and retention test, particularly on the drawings of electrocardiogram tracings. However, this group also averaged 45.5 minutes longer in completing the program during the learning phase. Considering that drawing may be a psycho-motor skill learned through practice, and that the extra time spent by the overt responding group may have been spent practicing this skill, the results of the above experiment are probably not generalizable to a situation where testing is carried out using a multiple choice or short answer type of test. Furthermore, the additional time spent by the overt responding group may mean that the results were due to this additional time and not to the mode of responding, or to an interaction of extra time and practice in drawing skills.

A further explanation for the discrepancy in results between the above experiments can be given as well. Skinner (1958:975) has pointed out that a response should be public, because when no overt, public response is made, covert responding often ceases. When one considers that the above group consisted of paid volunteers to whom learning about heart ailments had little or no relation to present or future educational plans it becomes apparent that covertresponding may well have ceased. However, had the program been one which fitted as an intrinsic part of a learner's curriculum, the results may well have been different.

Cummings and Goldstein (1964) in summarizing both their own results and those of some other researchers write that:

> Uniformly and without exception these numerous studies have found that it takes more time to go through a program when students are required to write their answers than when they are not. Cummings and Goldstein (1964:239)

For the purposes of this study the fact that overt responding requires more time than covert responding served as a strong reason for choosing the covert responding approach. Also it appeared from the literature that no proven benefits arise from overt responding. For the purposes of the design of this experiment it thus seemed best to use a covert responding approach.

THE HUMAN RECEIVER: SINGLE OR MULTI-CHANNEL

In designing a program of study one is faced with an even more fundamental problem than that of method of responding. This relates to the learner as a receiver of information. The human receiver gains information through his senses. Most learning programs are designed to use the channels of sight and hearing and are coded either pictorially or verbally. Whether or not the human organism can receive information coming through two channels at once is a question a programmer must ask, particularly if he would use both pictorial and audible-verbal information.

Of course, before a person decides to argue the question of whether a human receiver is single or multi-channel he must decide whether there is a reason for using more than one channel. In most instances pictures by themselves are probably not an adequate source of learning information. Many programs, however, do use print only and seem to be quite satisfactory. Nevertheless, Peter Pipe (1966) in a book called Practical Programming writes:

> A diagram is often useful for presenting basic information, or for providing the stimulus to which the student must respond. This may sound obvious, but the fact is that far too many programmers strive to verbalize what could much better be done with pictures. In your first program, you may be wise to stay with words as far as possible, but let me encourage you to experiment thereafter with programs that contain pictures. Peter Pipe (1966:75)

Gropper (1963) suggests further that:

> Visuals may be used to serve two basic control functions in promoting the acquisition, retention and transfer of responses. First they may be used to cue and reinforce responses

> so that the responses may be acquired and retained. Second they may be used as examples in order to foster generalizations of responses to new situations or in other words to establishing understanding. (1963:75)

Pictures are thus presented as a further possible addition to words in devising a program. Pictures are seen by the eye. If the verbal aspect of a program were to be presented audibly then the conflict arises as to whether a human is capable of receiving information on one channel only, eye or ear, or on more than one, e.g. through both eye and ear at the same time.

If one does present a program of learning materials utilizing two or more channels of the human receiver one may be regarded as attempting "multiple channel" communication. Hartman attempts to define ways in which information can be transmitted through multiple channels for learning purposes as follows:

> In multiple channel experimentation the relation of the information in each channel to the information in other channels should be specified...(a) two channels may present <u>redundant</u> information such as the same word written and spoken (b) Two channels may present <u>related</u> information such as a pictorial presentation of an object and verbal description of the object... Hartman (1961b:242)

For present purposes it is the question of "related" information that is most important.

Benefits of pictures in a program of learning have been supported as previously mentioned. However, when one wishes to show pictures accompanied by verbal commentary, especially oral-verbal commentary, one faces a problem. This problem is emphasized by Travers who writes:

> So far there does not seem to be a single contemporary scientist who takes the position that the human can receive more information if exposed to two or more sources simultaneously than if exposed to one, nor if the information is transmitted through two sense modalities rather than one. Travers (1964b:373)

There is, however, a theory which seems directly at odds with the above statement. This is called "cue summation." Severin (1967:233) says that "The cue summation principle of learning predicts that learning is increased as the number of available cues or stimuli is increased."

Hartman (1961:25-42) performed some research which seems to support the above idea, for he found that redundant information simultaneously presented by the audio and print channels is more effective in producing learning than is the same information in either channel alone. (1961:25-42)

Conway, (1967) supporting Travers' view, also presents a rationale which explains how Travers' results and those of

Severin both fit in with the view that the human acts as a single channel receiver of information.

> The perceptual system acts as a single channel with limited capacity. Under rapid rates of input presentation information from only one source or modality gains access to it at a given moment. Thus in the case of simultaneous presentation of redundant information through two modalities at rapid rates only part of the information can be processed, and no gain could be expected for the two modality presentation over a single modality presentation.
>
> However, at slower presentation rates the individual can switch attention from one modality to another and have access to a greater number of cues. This may allow for learning gains for the two modality presentation over a single modality presentation. Conway (1967:385)

Since this latter view tends to explain both Travers conceptual position and Hartman's experimental evidence, it is this latter view which provides a conceptual basis for the development of materials for this study.

DESIGN OF PICTURES IN LEARNING PROGRAMS

Any decision to use pictures in a program leads to questions concerning the amount of illustration and the kind of illustration which should be used. Lumsdaine advocates profuse illustration when he writes that:

> The prevailing tendency among film makers, and probably others who prepare instructional materials is probably to make too little use of repeated

> illustrations rather than too much. In cases where doubt exists, the decision to illustrate more fully or use more repetition than is thought necessary would very likely increase the training value of many instructional programs. Lumsdaine (1965:267)

The present program has been designed following Lumsdaine's advice. Such a move leads to learning steps which are short and provide for many review opportunities.

The pictures used are diagrammatic, for as Knowlton suggests:

> A detailed realistic picture may say too much. This is the reason why barren, highly schematized pictures are often used. By schematizing one hopes to eliminate noisy, noncritical attributes. Knowlton (1966:177)

Knowlton's idea is supported by experimental evidence such as that provided by Dwyer (1969:151) using a program on the heart utilizing both actual photographs and line drawings. Benefits in learning terminology related to the heart were shown for the diagrammatic approach.

Thus far review of the literature has related to the design of a program which is profusely illustrated and to a rationale for use of multi-channel presentations. The following discussion is related to the experimental variables examined in this study.

PACING TECHNIQUES

Programming which facilitates individual pacing of a learner through a program of instruction has been highly publicized in recent years, and even in the past it was looked forward to as possessing a tremendous advantage. As early as 1912 Thorndike wrote:

> If by a miracle of mechanical ingenuity a book could be so arranged that only to him who had done what was directed on page one would page two become visible, and so on, much that now requires personal instruction could be managed by print. Thorndike (1912:10)

The age of electronics has permitted Thorndike's vision to become partially true and modern prophets and modern researchers feel there is great promise in programs which allow students to learn at their own rate of speed. But questions have recently been raised concerning the value of such a mode of instruction. At this juncture readers should be reminded that only self-pacing is being discussed and not those aspects of educational planning which provide individual material for learner use.

Gropper, Kress and Gerard (1965) propose that presenting programs in a fixed-paced manner may have advantages over an individualized-pacing mode. They do not specify whether their statement applies to all classes of learners or only to specific classes. They write:

> To most programmers it may seem paradoxical, and perhaps even unsound to suggest that instruction may be more effectively individualized if it is fixed-paced rather than self-paced. While it is true that individuals do indeed have different pacing requirements it does not follow that the pace that individuals adopt necessarily meets their individual needs. A consistently fast self-adopted pace which leads to high error rate is clearly not compatible with the goal of instructional efficiency. These pacing failures are not hypothetical, they do occur. If learning effectiveness on the one hand or learning efficiency is to be improved, lessons delivered at a specially fixed pace may clearly be the remedial individualization needed by those who exhibit non-adaptive self-pacing patterns. Gropper, Kress and Gerard (1965:165)

Frye (1963:34) also found in his research that group pacing procedures led to improvements in efficiency. His experiment used homogeneous and heterogeneous grouping as a variable. Basically his experiment showed that a relatively homogeneous group can participate in a group-paced program with savings of average time spent per individual, and with no loss in learning.

This does tend to raise a question concerning classes in university or in nurses training where the students have a certain level of homogeneity due to achievement on standard examinations as a prerequisite to entry. Such a group may be homogeneous enough that group-pacing would provide equal learning to self-paced groups as shown on an immediate post-test and a delayed retention test with an additional advantage of substantial savings in time spent.

This is a pertinent question, for at the moment a great deal of money and effort has gone and is going into plans for individualizing instruction on a broad scale. Postlethwaite (1969) describes a program known as the "audio-tutorial approach to learning." Here high emphasis is placed on the value to the individual of progressing at his own pace.

This technique is becoming increasingly popular. The Washington Hospital School of Nursing (Deegan, Deiter, and Voelker, 1968) has established an audio-tutorial division of instruction. In fact, reports at audiovisual and educational conventions and reports in educational magazines give evidence to its growing acceptance.

A good deal of this popularity may be due to a "bandwagon" appeal". This study seeks to provide additional empirical evidence on the question of individual pacing versus group or media-pacing.

As Gropper, Kress and Gerard (1965:168) indicate there exists the distinct possibility that students rapidly develop a stylistic performance, a consistent work rate and error pattern on programs that is neither efficient nor conducive to the best learning results. Thus in the long run a fixed-paced program may be more efficient and produce more learning, or at least as much learning on the average, as an individualized pacing mode, time factors being equal. The above mentioned individuals write:

> It is unsound to assume that instruction is individualized simply because each student is allowed to adopt his own pace. It is equally unsound to assume that instruction is not individualized simply because presentation tempos are externally determined with no student allowed to adopt his own pace. The most trustworthy evidence that instruction has indeed been individualized comes from dependent measures describing group performance reflecting widespread learning effectiveness and efficiency. Gropper, Kress and Gerard (1965:166)

EFFECTIVENESS OF AUDIO-VERBAL INSTRUCTION VERSUS PRINTED-VERBAL INSTRUCTION

Thus far the literature supports, or shows little evidence to oppose, the type of programmed learning using short steps, covert responding, and repeated diagrams in conjunction with verbal instructions to help convey desired information to learners. The literature has, however, revealed problems in the area of self-pacing as opposed to group or media-pacing. A further problem relates to whether one should use printed, verbal instructions or audible, verbal instructions.

For example Knowlton says that presenting a verbal message in audible form or printing a verbal message has not altered the coding or sign type, which means that the same cues will be presented to learners, and hence no significant differences can accrue to learners by presenting verbal information in one mode or the other. Knowlton (1960)

However, much of the time and efforts of Postlethwaite and others who are working in the audio-tutorial instruction area are devoted to taping a sequence of study activities in the voice of the senior instructor for the student "to direct and supplement his study effort." Postlethwaite (1969:7)

Another reason for an audible presentation, may be that expressed by Harden in the Scottish Medical Journal.

> The spoken word has advantages over a text read in a book. The spoken word can capture the lecturer's personality and by suitable intonation can more easily transmit to the student the correct emphasis. Harden (1968:207)

Anderson (1966:503) concludes:

> ...the involvement of the aural channel requires from the receiver a heightened level of attention. The receiver knows from past experience that he must quickly integrate the information given because the aural message lacks referrability.

In spite of such support for the audible mode, experiments in this field do not provide consistent results. In an experiment performed by Van Mondfrans and Travers (1964) in learning of a word list it was found that on a written recall test there was no difference between a visual group, an audio group, or a group that had both an audio and a visual presentation. Hartman, (1961b) however, after an extensive review of research, suggests that the print channel becomes more effective in relation to the audio as the difficulty of the material increases. This is, of course, true only for literate subjects. Where subject matter is very simple or young children are learning, he suggests that audio seems best.

Much of the research in the area of audio-verbal presentations versus printed-verbal presentations has involved learning printed word lists in a laboratory setting. That results can be extrapolated from such experiments to normal learning environments where conceptual development and not simple rote learning is involved is highly doubtful.

Hardin has stated that the audible presentation in capturing the accented and emphasized points as well as the speaker's character may engage the learner's attention and so provide for greater learning. On the other hand, the average reader may be able to read faster than the average speaker talks. This would enable a person reading instructions to finish in less time than one listening to a tape.

In this study the same number of words occur in both printed and audio-taped versions. Learning gains, retention scores and time factors are measured. The results should prove helpful to those desiring to establish priorities for the written-verbal versus the audio-verbal presentation. Should learning differences and time differences be negligible between the above variables then the question becomes one of logistics, or practical application, in the local situation.

Chapter III

METHOD

This chapter discusses methods and procedures which were used in organizing and preparing for this experiment. An explanation is given of the programmed materials and procedures used in preparing the program. Discussion of the test instrument occurs and questions of validity and reliability are considered as they relate to this instrument. Further discussion involves details of random assignment to groups and details regarding actual operation of the experiment. A description is also given of physical facilities and statistical procedures.

STIMULUS MATERIALS

A number of good multi-media materials are available in anatomy and specifically on the anatomy of the ear. However, to provide sufficient programs for this investigation utilizing such materials would have been prohibitive in cost. Further, behavioral objectives would then have had to be formulated to match the available materials rather than developing desired behavioral objectives and then preparing materials to match the objectives. Thus it seemed necessary to privately produce stimulus materials for this investigation.

Since knowledge of terminology and function were prime considerations, diagrams, not realistic photographs, were used. (Dwyer, 1968) To develop these diagrams several factors were influential. First of all the investigator discussed content with the senior anatomy instructor. He examined detailed notes used by the instructor as well as previous tests which had been given. The investigator also viewed films and read several books relating to the anatomy of the ear. He drew as well on basic information he had gained in a Bachelor of Science program in Zoology.

With this essential background, design of the actual program began. The learning materials were meant first of all to produce an understanding of the system that makes up the hearing apparatus, and secondly to provide factual knowledge and a working vocabulary.

Behavioral objectives were then designed that would lead students step by step to an understanding of the system of elements and interaction of these elements which work together to produce the mechanism of hearing. After these objectives had been analyzed by the anatomy instructor, by a professor in the audiovisual department at the University of Alberta, as well as by a communications class in the University, they were used to devise study frames for the program.

In preparing visuals for each study frame great care was taken to repeat diagrams or parts of diagrams several times. A total of sixty-seven slides were used in the program. Six further slides were produced for testing purposes. In producing the slides the procedures stated below were followed in order to assure quality diagrams and to assure that each slide contained information essential to a particular program frame.

Copies of pictures on the anatomy of the ear were made from anatomy books using a 35 mm single lens reflex camera with black and white film. The negatives were developed and mounted in slide frames for use in a slide projector. The image was projected into a mirror set at an angle and reflected up through a translucent glass table top. Technical pens with India ink were used to trace the pertinent parts of the projected image on tracing paper. The slide projector was moved various distances from the mirror to provide an appropriately sized image.

After the series of diagrams was completed on the tracing paper inside a frame no larger than five inches high and seven inches wide labels were typed on using a primary typewriter with carbon ribbon. The diagrams were then transferred to acetate using a thermofax process.

Color was added to these large transparencies using a diazo process. The outer ear was color-coded cyan, the middle ear blue, and the inner ear red.

After the series of diagrams was completed on large sheets of acetate, with colour coding provided by overlays of coloured diazo film the diagrams were placed on a light table in a dark room. A 35 mm single lens reflex camera with ASA 64 Ektachrome film was used to copy the diagrams. Accuracy of colour was not important; thus the difference between the colour temperature of the light produced by the light table and white light was not important.

The tape recording used in the investigation was produced in conjunction with the senior anatomy instructor using her voice. Pauses were placed where it seemed advisable, and end of frame signals applied.

Verbal-printed instructions were provided in booklets. These booklets were made using an I.B.M. electric typewriter with carbon ribbon using ten pitch Courier type. Copies were made using a spirit duplicating process. After each booklet was assembled it was examined to ensure legibility.

A further dimension was added to this study by preparing a questionnaire, in consultation with the senior instructor, which related to students' preferred learning modes. Students answered questions on the questionnaire at the same time they wrote their retention test. This questionnaire is included in Appendix C. Recorded with each item in the questionnaire is a record of student responses.

TEST INSTRUMENT

After completion of the program frames a test instrument was devised. A copy is included in Appendix D. A total of thirty-seven items were included on this test. Nineteen of these asked the students to write out the names of parts of the ear pointed to by lines on a diagram. Five questions asked the student to write out a short answer. There were eight multiple choice items with four choices in each item. Students were instructed that one or more items could be correct. Thirteen possible correct choices were included.

The program on which test items were based was first of all designed to meet behavioral objectives. The test was constructed in view of the behaviors asked for in these objectives. As a result the test is relatively straightforward. As many questions as possible were devised without one question's providing clues for answering another.

Validity

The program had been checked by anatomy instructors to see that material matched the curriculum and the program was based on specific behavioral objectives which were also the base for the test instrument. The production of a test in this manner should assure that one is checking for responses desired by the examiner, the essential ingredient of validity.

For example a specified behavioral objective might be: "The student, given a diagram of the ear with lines pointing to parts to be named shall be able to write out the names of the parts pointed to." The test is just a check that such a specified behavior has been acquired by the learner.

Gagné says of such tests that they are:

> ...direct measures of the desired criterion performance described in the behavioral objectives. Only an exercise in precise thinking is required to determine that the tests are indeed valid. No "correlation coefficients" are needed in justifying the tests in terms of the objectives, because we have set out to measure the desired performance as stated in the objectives as directly as possible. Gagné (1970:55)

Reliability

A test of this type does, however, present problems relating to its reliability according to generally accepted criteria. According to Thorndike and Hagen when we discuss the reliability of a test

> We are now asking not what it measures, but how accurately it measures whatever it does measure. What is the precision of our resulting score? How accurately will it be reproduced if we measure the individual again? Thorndike and Hagen (1969:177)

Such questions as these apply where students are tested at the end of a course of study, or at the end of a long unit. For example student nurses may write a test at the end of their first year which deals with all aspects of their study in anatomy. Naturally every possible question cannot be asked, but the test which is given should be an accurate measure of a learner's knowledge of the course. Also results should be reproducible. Such tests are usually designed to distribute students over a normal curve, and measures of reliability are largely based on the test's ability to place students in a percentile ranking.

Normally such a test is formed by sampling a large population of possible questions. One then expects learners to achieve in a manner which will have student achievement ranging over a normal curve and a set of statistical procedures are available to estimate reliability.

For example, to check for reliability, one can choose questions at random from a large pool of questions and administer them to students. Later one can choose another group of questions from the same pool and administer these to the same students. Analysis of comparative results can indicate the reliability of the original testing process.

If one has a long test, rather than re-administering a similar test at a later date, one can discover achievement on even numbered questions, and compare this to achievement on odd numbered questions, using, for example, the Spearman-Brown Prophecy formula Thorndike and Hagen (1969:183-185).

However, reliability coefficients are difficult to derive when tests are relatively short and designed for criteria levels of performance. Thorndike and Hagen (1969:189) suggest that the longer the test the higher is the probable reliability. They write further that:

> If a test is very easy for a group, so that all of them can do most of the items very easily, it may be expected to be ineffective in discriminating among the members of the group. When everyone can do the easy items, it is as if we had shortened the test to just the few harder items that some can do and some cannot. Thorndike and Hagen (1969:191)

This is precisely what happens in a criterion test based on behavioral objectives. One prepares learning activities designed to produce specific behaviors, and then tests for those specific behaviors. Such a procedure should reduce error of measurement, and any error which does exist would be difficult to assess. Thus it would seem, that when testing for a short program based on behavioral objectives where all possible test items are used, that it is difficult to assess the reliability of the test using conventional measures.

EXPERIMENTAL PROCEDURES

Alberta's largest school of nursing is the Royal Alexandra Hospital School of Nursing in Edmonton where first year classes average between 100 and 120. For this experiment the population was the first year class of 118 students. From these students a random assignment was made to one of four experimental groups for a total of twenty per group. Since the program of study was an integral part of ongoing instruction the remainder of the students attended class under their regular instructor.

This aspect of the experiment in which programmed instruction was compared with normal instruction is difficult to analyze. As Schramm writes:

> Experimental psychologists typically do not take very seriously the evaluative experiments in which learning from programs is compared with learning from conventional teaching. Such experiments are doubtless useful, they say, for school administrators or teachers to prove to themselves (or to their boards of education) that programs work. But whereas one can describe fairly well the characteristics of a program, can one describe the characteristics of a classroom teaching situation so that the results of the experiment can have any generality? What kind of teacher is being compared with what kind of program? Schramm (1964:83)

It is mainly because of the local interest that results of the normal group comparison with the other groupare included. Also, though statistical comparisons are questionable, widespread experiments of similar nature may produce a body of information useful to educational planners. These results are thus included for those who may be interested even though the investigator is fully aware of their lack of generalizability.

Approximately one month before the experimental treatment, December 22nd, 1970, all first year students were given a pre-test on the anatomy of the ear. At this time they were unaware of future implications. They were simply told it would provide important statistical data and that they should do their very best.

This same test was given as an immediate post-test after students had completed the program, and again two weeks later as a retention test. Since all groups receiving the tests had equal opportunity to learn through the actual testing process, this should not affect the experimental results. Also no feedback was provided concerning test results during the experiment which should have kept learning through the testing process to a minimum.

There were four main experimental groups, labelled A, B, C and D for purposes of the experiment. As mentioned previously all four programmed presentations had 35 mm slides as a visual information source. Groups A and B were media-paced, that is pacing speeds had been pre-determined. Groups C and D allowed for students to progress at a speed each considered optimal, with opportunities to review at will. Groups A and C used tape-recorders to receive audible-verbal instructions. Groups B and D had booklets containing printed-verbal accompaniment. These groups and treatment modes are summarized in Table 1 below.

Table 1. Groups and Treatment Modes

(35 mm slides are a constant source of pictorial information in the following four groups)

Groups	Pacing	Verbal Presentation
A	Media	Audio
B	Media	Print
C	Individual	Audio
D	Individual	Print

Besides the four main experimental groups, a fifth group, Group E, was also included. This group received instruction through a lecture and textbook reading approach, which was the usual technique of the regular classroom instructor.

Preparations were made for using two programs at the University of Alberta in Edmonton for analysis of data. The first program included an analysis of variance with a chi squared test for showing homogenity of variance and a Sheffe Multiple Comparison of Means.

The second program was an analysis of covariance using the results on the pre-test as a covariate. It was planned to use the analysis of covariance only if analysis of variance on the pre-test indicated that the random sampling had chosen groups with significant differences in achievement on the pre-test.

After the pre-test was written, test numbers from the already randomly distributed papers were copied onto slips of paper. These slips were placed in a box, mixed, drawn at random, and the students assigned to groups A, B, C and D. Individuals remaining were assigned to group E. Thus each individual had equal opportunity of being assigned to any group.

PHYSICAL ARRANGEMENTS

Four rooms in the school of nursing were provided for the experiment. One of these was the regular lecture room, and the regular instructor used it. Another very large seminar room was used for individual instruction. In this room were arranged twelve Kodak carousel slide projectors stationed to give a picture about twelve inches wide. With six of the slide projectors were cassette audio-tape machines fitted with earphones. With the other six projectors were programmed booklets. Individually-paced students, Groups C and D, came in as a group, were given instruction in the use of the instruments and in the format of the program and were given opportunity to ask questions about equipment and procedures. When all students were ready to begin, time was recorded, and all students began together. When a student completed the program she reported to the investigator who was personally in charge of this group, had her elapsed time recorded, and was given the post-test.

Groups A and B, the media-paced groups met in separate rooms. A registered nurse who was well acquainted with the program and instruments of instruction was in charge of group A, the audio, media-paced group. This group received initial instructions on tape. After these instructions students had opportunity to ask questions regarding program procedures. They then studied the programmed materials as a group. The nurse in charge operated the tape recorder, an Ampex 850 with two extension speakers, turned on the slide projector and then advanced the slides at an audible signal. When the program was completed, students immediately wrote the post-test.

Group B, the print, media-paced group met in another room. The person in charge was one of the regular first year instructors. When students were settled, she read an explanation of experimental procedures and then handed out booklets containing printed, verbal programmed material identical to that on tape. After students were acquainted with proceedings, the instructor turned on the slide projector. Students turned a page of their booklets each time the slides changed. The instructor in charge listened to a tape identical to one used by the audio, media-paced group and changed slides on signal. Use of earphones by the instructor enabled her to change slides according to signal without having students hear the tape.

As each group proceeded through the program members were expected to respond covertly. Information frames were followed by frames which asked questions of the students. Students thought out responses, and then a frame supplying answers was provided. The program was designed to provide decreasing prompts and so move the student closer to a test situation.

In the media-paced groups, pacing was mechanical, as mentioned, and utilized only the reviews and test frames incorporated in the program for review purposes. However, individually-paced learners could pause on any frame, they could turn back and repeat frames, or if a frame were redundant to a particular learner it could be quickly passed over.

As mentioned, immediately after completing the program students were given a post-test. Two weeks later the same test was given as a retention test. These tests were marked by a registered nurse, not by the investigator. The tests were objective, so in reality any literate person could have done the grading. However, it was useful to have one do the grading who was already conversant in the terminology.

After grading was completed the test papers were divided into their respective groups and the grades were recorded.

It should be noted that the senior anatomy instructor who had taught the "normal" group had participated in devising and revising the behavioral objectives, and had approved the evaluation instrument. Her instruction consisted of lectures illustrated with five overhead transparencies. Students were also given time to read the textbook. These students were also able to ask questions of the instructor.

Scheduling for the experiment produced some problems. Four rooms were provided and only twelve sets of stimulus materials were available. To have instruction carried on for all students at one time would have required one set of materials each for groups A and B and forty sets for the students in the individualized pacing groups. Thus all groups could not be tested at the same time. However, as much overlap as possible was arranged. The experiment ran two days. On the first day the large groups all received instruction beginning at 2:00 p.m. At 1:45 on Day One five individuals from each of the individually-paced groups received instruction. Two hours were allowed for completion, though no individual required more than seventy minutes. Beginning at 4:00 p.m. six more from each of the individualized-pacing groups received instruction.

On the following day beginning at 1:30 p.m. the same procedure was repeated and again at 4:00 p.m. In this way more than half the individually-paced people received instruction at approximately the same time of day as those in the media-paced groups. It is very difficult to assess the influence on the final results due to this time disparity, but hopefully it is minimal.

Students were also assured that though the materials in question were important to them, and were a basic part of their curriculum, test results would not become part of their records. This was meant to ease tension, and also keep to a minimum students' preparing for the second day's learning experience.

The media-paced groups, both slide-tape and slide-booklet took thirty-eight minutes for their program. This is omitting about two minutes given about two-thirds of the way through the program for a brief break. These groups received instruction in areas where students could sit in good position relative to the screen. No student was closer than two screen widths from the picture nor further than six screen widths from it. Also no student had to observe from a position more than forty degrees off axis to the centre of the screen.

For those in the individual pacing mode, carousel projectors were placed on tables, and a picture projected onto a white wall. The short throw enabled a bright image to be projected even in a fairly well lighted room. Students could thus both see the visuals and read their printed booklet where booklets were part of the experiment.

Each booklet had a page number corresponding to the slide being projected. The slide and printed page of the booklet served as a learning frame for the program for groups using print.

On the slide-tape part of the program a frame consisted of the slide and appropriate taped commentary. A signal indicated the end of a frame and revealed the need for a new slide which would match the commentary coming after the signal.

In the media-paced groups instructors handed out tests immediately after the program was completed. In the individually-paced groups learners asked the instructor for a test when they were satisfied that they had finished the program.

PROCEDURES FOR STATISTICAL ANALYSIS

Since the purpose of the study was to compare the effects of various presentations of a program of study, it was necessary to use statistical procedures which would compare the means of the different groups and give estimates of the probability of a particular mean differing from one or all of the other means by chance.

Since all treatments about which inferences were to be drawn were included in the analysis, and any replication of the experiment would involve repetition of the same treatment levels, a fixed-effects model was appropriate for analysis Kirk (1968:51).

Kirk (1968:59) further suggests that "analysis of variances using an F ratio provides a test of the hypothesis that all treatment population means are equal."

Thus an analysis of variance, fixed-effects model, was used to analyze the data collected in this study.

In performing the analysis of variance it was necessary that certain assumptions be met.

The first of these assumptions is that scores must be randomly sampled from a normal population. One may probably assume that the particular first year class included is representative of other first year classes with similar backgrounds in hospital nursing programs.

The students from this first year class were randomly assigned to groups and were also given a pre-test to determine whether random selection within the first year class had produced approximately similar groups.

With analysis of variance, violations of the normality assumption are generally not considered to be serious. Kirk writes:

> Studies by Pearson (1931) and Norton as cited by Lindquist (1953) indicate that the F distribution is relatively unaffected by lack of symmetry of treatment populations. . . . For the fixed-effects model an experimenter need not be concerned if the K populations are homogeneous in form, for example all treatment populations positively skewed. . . . In general, unless the departure from normality is so extreme that it can be readily detected by visual inspection of the data, the departure will have little effect on the probability associated with the test of significance.
> Kirk (1968:61)

A second assumption is that there is homogeneity of population error variances. To assure that this assumption was met a chi square homogeneity of variance was run with data for each statistical hypothesis. This test was meant to reveal whether varainces within classes were homogeneous, that is whether or not variances within classes differed significantly among themselves.

It tells whether or not variance 1 = variance 2 = variance 3, etcetera, for each statistical hypothesis.

In addition to the above statistical procedures a Scheffe multiple comparison of means was included. This was meant to supplement analysis of variance data and provide comparisons which would relate every treatment mean with every other treatment mean. This meant that while comparisons among groups occurred in the analysis of variance, direct comparisons between groups was also possible. The tables relating to this feature occur in the form of a grid with vertical and horizontal components. Each figure which helps to form the grid is a probability figure relating two experimental means.

Readers should also note that data under the "p" in the analysis of variance tables are of major consequence. This is the final figure in each table. Data occurring under the p refer to the probability of the difference in the obtained group means occurring by chance.

Chapter IV

RESULTS AND DISCUSSION

For groups involved in this experiment a non-statistical hypothesis suggested by the review of the literature was that individually-paced groups would take longer on the program than media-paced groups on the post-test and retention test. Also suggested was that the individually-paced audio group would take longer than the individually-paced, print group in the present situation.

Specific experimental hypotheses were tested as null hypotheses. These were first of all formulated as among groups hypotheses. Such analysis compares all groups at once. If differences are significant this fact will be noted. One can then take a further step and make a careful examination comparing individual groups to find the source of the significant difference. Analysis comparing individual groups with each other would occur using between group hypotheses. Such hypotheses have been formulated in chapter 1. They will be repeated in this chapter only if a significant difference is noted in the among groups analysis.

It may be helpful at this point to remind the reader concerning the identity of the groups included in this study. They are as follows: Group A, audio-verbal, media-paced; Group B printed-verbal, media-paced; Group C, audio-verbal, self-paced; and Group D, printed-verbal, self-paced. All these groups had slides as a constant source of visual information. The four presentations just mentioned represent the two main experimental variables, pacing and verbal presentation.

A further group, Group E, a normal group was included in the analysis as well.

In the statistical analysis which follows the level of significance which was accepted is the 0.05 level. Next in order are the statistical hypotheses with tables and commentary.

Hypothesis I

There is no significant difference among the four experimental groups (A, B, C and D) on

a. pre-test performance

b. post-test performance

c. retention test performance

The first step, following the above hypothesis, was an analysis of variance on the group means of pre-test scores. According to results of the analysis of information relating to this hypothesis using analysis ov variance techniques the null hypothesis was not rejected for hypothesis I (a) since the probability that the results occurred due to chance was 0.19. With this factor supporting the conclusion that random sampling did provide for homogeneous grouping further analysis of variance on post-test and retention test data was undertaken. Table 2 on pre-test data follows.

Table 2. Analysis of Variance on Pre-test Scores for Experimental Groups

Group	Number	Mean	Variance	S. Dev.
A	19	10.95	4.28	2.06
B	19	12.21	12.29	3.51
C	19	10.42	6.03	2.46
D	17	10.71	6.22	2.50
Total	74	11.08	7.31	2.71

Homogeneity of Variance Test Chisq. = 5.4641
Probability = 0.14

Analysis of Variance

SOURCE	SS	MS	DF	F	p
GROUPS	0.353×10^2	11.75	3.	1.62	0.19
ERROR	0.506×10^3	7.23	70.		

Had group means varied significantly on the pre-test an analysis of covariance using the pre-test as a covariate would have been used for further statistical analysis. As mentioned this was unnecessary. Table 2, just presented, gave results relating to pre-test scores for the four main experimental groups, and indicated that no significant differences occurred. Analysis of variance on post-test scores again revealed no significant differences among groups A, B, C and D. With 3 and 70 degrees of freedom a probability of 0.47 was obtained. As a result the null hypothesis was not rejected for hypothesis I (b).

Although the data revealed no significant difference among groups, Group D, as shown in Table 3 had a larger variance than any of the other groups. Group D's variance is 20.86 compared with an average of 13.94 for the four groups. This can probably be accounted for by chance since this group contained both the lowest and the highest scores attained by students on post-test scores as shown in Appendix E. Two students obtained a score of 36 and one obtained a score of 22 in Group D. Highs and lows in the other groups are as follows. Group A had a high of 34 and a low of 24, Group B had four students with 35 and one with 25, Group C had one with 34 and one with 23. It would also appear from close examination that the scores in Group D seem to cluster more closely around the group mean with the exception of the high and low scores than do the other three groups.

This would account for the large variance, and would probably be accounted for by chance rather than by a peculiarity in the learning method.

Table 3 follows with details of the analysis of variance on post-test scores.

Table 3. Analysis of Variance on Post-test Scores for the Four Main Experimental Groups

Group	Number	Mean	Variance	S. Dev.
A	19	30.58	10.59	3.26
B	19	31.32	11.67	3.42
C	19	29.42	14.48	3.81
D	17	30.12	20.86	4.57
Total	74	30.37	13.94	3.73

Homogeneity of Variance Test Chisq. = 2.33
Probability = 0.5076

Analysis of Variance

SOURCE	SS	MS	DF	F	P
GROUPS	0.360×10^2	12.00	3.	0.84	0.47
ERROR	0.995×10^3	14.22	70.		

Following is Table 4 which presents a probability matrix for the Scheffe multiple comparison of means on the post-test scores. In this table it is apparent that no group mean differed from any other group mean. Note that a comparison between Group B and C presents the lowest level of probability at the 0.49 level.

Table 4. Probability Matrix for Scheffe Multiple Comparison of Means on Post-test Scores

		GROUP			
G		A	B	C	D
R	A	1.00	0.95	0.83	0.99
O	B	0.94	1.00	0.49	0.82
U	C	0.82	0.50	1.00	0.96
P	D	0.99	0.82	0.95	1.00

On the final aspect of Hypothesis I, Hypothesis I (c), namely that there is no significant difference among the four experimental groups on retention test performance, a probability of 0.51 was obtained. This led to failure to reject the null hypothesis in relation to retention test scores. Group B, did, however, appear to be somewhat different from the other groups. This was in line with findings on the pre-test which indicated results slightly above the other groups but not significantly so for this group. Examination of Table 2 on page 68 will reveal this.

Table 5 presents the results of the analysis of variance with the retention test scores as the criterion and is given on the following page.

Table 5. Analysis of Variance on Retention Test Scores for Four Experimental Groups

Group	Number	Mean	Variance	S. Dev.
A	19	21.37	32.47	5.70
B	19	24.26	46.76	6.84
C	19	22.74	23.54	4.85
D	17	22.71	33.35	5.78
Total	74	22.77	33.29	5.77

Homogeneity of Variance Test Chisq. = 2.07
Probability = 0.56

Analysis of Variance

SOURCE	SS	MS	DF	F	P
GROUPS	0.798×10^2	26.59	3.	0.78	0.51
ERROR	0.238×10^4	34.05	70.		

The probability matrix for the Scheffe multiple comparison of means for the retention test is also included. Again the Scheffe analysis indicates that there is no significant difference between any two groups. Table 6 with this information follows.

As with post-test results a comparison between Group A and B shows the least probability of occurring by chance with a probability level of 0.51 which is still far from a significant level.

Table 6. Probability Matrix for Scheffé Multiple Comparison of Means for Retention Test Scores

		GROUP A	GROUP B	GROUP C	GROUP D
GROUP	A	1.00	0.51	0.91	0.92
	B	0.51	1.00	0.88	0.89
	C	0.91	0.88	1.00	1.00
	D	0.92	0.89	1.00	1.00

Hypothesis II

There is no significant difference among the four experimental groups in the time taken to complete the program.

Since analysis of variance demands that individuals in a group have varying scores so that a mean of different scores can be taken, and since groups A and B had uniform times it was impossible to run an analysis of variance for this hypothesis. Rather the mean time spent for each group will be noted and comments made without reference to significant difference in a statistical sense.

Groups A and B each took 38 minutes in the media-paced presentations. Group C, the audio-verbal, self-paced group took 60.11 minutes and group D, the printed-verbal, self-paced group took 53.12 minutes. Other than Groups A and B it does appear that substantial differences in mean time taken to complete the programs did exist. This difference in time existed without, as has been previously noted, any significant difference in average achievement. Particularly one can note that the media-paced groups required less time than the individually paced groups. Also, the audio-verbal, self-paced group took longer than the printed-verbal, self-paced group. Much of this time difference should be attributable to the variation in verbal presentation. In other words, what is being suggested is that a program using printed verbal information rather than audible verbal information will be more efficient in use of student time. If this is true, then one ought to be able to take the printed-verbal, media-paced group and present information to it in a still shorter time than the period used without there being a statistically significant difference in learning achievement from the other groups in this experiment. However, many other factors might become involved, and only after substantial further experimentation could one make any authoritative comments. Such careful experimentation might, however, suggest some guidelines on the comparative times necessary for media-paced programs using printed verbal instructions as opposed to audio-verbal instructions.

Although data are not available showing statistically significant differences on the mean times of groups in completing the program, it is probably the time element of this experiment which is most significant to educational planners. If the results of the above data can be extrapolated to learning environments where programs are in general use then any savings in time per individual program without loss to learning is important.

Table 7 which follows presents the mean times spent by each group.

Table 7. Mean Times in Minutes Spent in Four Programmed Experimental Presentations

Groups	Number	Mean
A	19	38.00
B	19	38.00
C	19	60.11
D	17	53.12
Total	74	48.31

What follows next is similar to the analysis which has just been concluded. The difference is that a group which received instruction in the method normally used with anatomy classes at the Royal Alexandra Hospital is included in the comparison. The normal procedure was to use a lecture and textbook reading approach.

This comparison is presented as a matter of local interest, and also to show that the programs used in the experiment were at least as effective in instruction as the method normally used.

Hypothesis III

There is no significant difference among the five groups (A, B, C, D and E) on

a. pre-test performance

b. post-test performance

c. retention test performance

When the normal group is included with the other four groups in pre-test analysis, (Hypothesis III .a) a probability of 0.26 leads to failure to reject the null hypothesis that there is no significant difference among the group means of the five groups on pre-test analysis.

Table 8 presents the analysis of variance data on pre-test scores for the four experimental groups and the normal group.

Table 8. Analysis of Variance on Pre-test Scores for Four Experimental Groups and a Normal Group

Group	Number	Mean	Variance	S. Dev.
A	19	10.95	4.28	2.07
B	19	12.21	12.29	3.51
C	19	10.42	6.03	2.46
D	17	10.70	6.22	2.49
E	24	10.75	6.19	2.49
Total	98	11.00	7.00	2.65

Homogeneity of Variance Test Chisq. = 5.67
Probability = 0.23

Analysis of Variance

SOURCE	SS	MS	DF	F	P
GROUPS	0.372×10^2	9.31	4.	1.33	0.26
ERROR	0.649×10^3	6.98	93.		

Analysis of Variance on post-test results, Hypothesis III (b), yields a significance level of $p < 0.001$. Since analysis of variance of the means on achievement tests for groups A, B, C, and D alone revealed no significant difference among groups, it would seem apparent that the above probability level is due to the inclusion of the data relating to the normal group.

The reasons for this statistical result just mentioned are difficult to assess with any degree of certainty. One may, however, suggest several possible causes.

One main reason may be the structure of the learning program based as it was on behavioral objectives with each instructional frame aimed at producing a particular behavior. Students also had opportunity to respond to each frame and have their response checked for correctness. This meant that students in the program had opportunities to practice responses or behaviors later asked for on the test instrument. Such opportunities are difficult to offer with normal lecture and textbook reading procedures, and may point to an inherent advantage of programs in the kind of learning where specific behavioral objectives can be formulated.

Another reason for the differences in achievement may be due to the nature of the test. The test was based very specifically on the original behavioral objectives. It is true that the lecturer in the regular instruction group had examined these behavioral objectives, the learning program, and the test instrument and made several suggestions regarding their formulation, but these items were not her personal production. Thus emphasis in her lectures would probably not match the emphasis of the learning program. This would be particularly true in relation to the way the program approached hearing as a transformation of energy to different forms. Four possible responses in the test instrument are linked to this approach, and could possibly account for part of the difference in achievement scores. Furthermore, the vocabulary, type of wording, and general presenation of the program would likely match the test more closely than would the regular instructor's presentation. This might affect test performance. Another problem may have resulted from the nature of the textbook reading for which students in the normal group were responsible. Since it was not organized in a step by step fashion it may have represented a harder learning task than the programmed materials. These students also had to guess about which parts of the reading and lecture would be on the test, whereas the programmed groups had all aspects emphasized which they were expected to learn.

Most of these items which have been offered as reasons for the difference between the programmed and normal group may simply be inherent advantages of a programmed prsesentation over most other learning modes.

Following is Table 9 with details of analysis of variance for post-test scores for the groups just discussed. In the following tables an asterisk is placed beside each element of the data which indicates a statistically significant comparison.

Table 9. Analysis of Variance on Post-test Scores of Four Variations of Programmed Presentation and a Normal Presentation

Group	Number	Mean	Variance	S. Dev.
A	19	30.58	10.59	3.25
B	19	31.32	11.67	3.42
C	19	29.42	14.48	3.81
D	17	30.11	20.86	4.57
E	24	23.83	11.19	3.34
Total	98	28.77	21.03	4.59

Homogeneity of Variance Test Chisq. = 2.80

Analysis of Variance

SOURCE	SS	MS	DF	F	P
GROUPS	0.809×10^3	202.27	4.	15.02	< 0.001*
ERROR	0.125×10^4	13.47	93.		

The results of analysis of variance which indicate that a significant difference on post-test results occurred is enlarged on in the probability matrix for the Scheffé multiple comparison of means. Analysis shows that Group E varies from all the other groups at a significance level of $p < 0.001$. Table 10 which follows presents the Scheffé analysis.

Table 10. Probability Matrix for Scheffé Multiple Comparison of Means on Post-test Scores of Four Variations of Programmed Presentation and a Normal Presentation

		GROUP				
		A	B	C	D	E
G	A	1.00	0.98	0.91	1.00	<0.001*
R	B	0.98	1.00	0.64	0.92	<0.001*
O	C	0.91	0.64	1.00	0.99	<0.001*
U	D	1.00	0.92	0.99	1.00	<0.001*
P	E	<0.001*	<0.001*	<0.001*	<0.001*	1.00

When results were analyzed for retention test performance, the results were no longer significant. However, the probability that a comparison of means occurred by chance is still much less than when only the programmed groups were compared. Analysis of variance on Hypothesis III (c) yields a significance level of $p = 0.10$. When only the four groups were compared the probability level was $p = 0.51$.

A variety of reasons might account for the failure of the retention test to show significant differences similar to the post-test. With the passing of time it would seem probable that new information would tend to be forgotten more quickly than information which had been relearned a number of times. The information learned by students in this experiment would represent a relearning task for many students since they would previously have studied the anatomy of the ear one or more times during their public school years. The present study would simply be in more detail than any previously encountered. A part of the student test scores in this experiment should reflect this previous knowledge. In fact scores on the pre-test probably indicate this knowledge as well as reflecting lucky guesses. Groups which showed the highest mean scores on post-tests should be the ones which learned the most new material, mean scores on pre-tests being similar. It is possible that this new material, not having the opportunity of re-enforcement applying to material which is simply relearned, is the material which is forgotten soonest. For example on post-test scores there was no significant difference among groups for the four programmed groups and the mean score was 30.37. For the normal group the score was 23.83. The difference between these two scores would represent a difference, in some degree at least, of new material learned. If new material is that which is soonest forgotten, then in the two weeks between post-test and retention test there would be a levelling out of scores as students forget a large percentage of new material learned but retain most of the material relearned. On the retention test when only the four groups were compared the mean of the four groups was 22.77 with the lowest score being 21.37. The score of the normal group on the retention test was 19.70. The above is speculation and would be difficult to verify, but could possibly provide a further research topic.

As already noted the difference among the five groups is not statistically significant, yet as a matter of interest it is apparent that the group receiving normal instruction did not achieve as well as the programmed groups.

Table 11 follows with details of analysis of variance for the five groups on retention test scores.

Table 11. Analysis of Variance on Retention-test Scores of Four Variations of Programmed Presentation and a Normal Presentation

Group	Number	Mean	Variance	S. Dev.
A	19	21.37	32.47	5.70
B	19	24.26	46.76	6.84
C	19	22.73	23.54	4.85
D	17	22.70	33.34	5.58
E	24	19.70	24.04	4.90
Total	98	22.02	32.51	5.70

Homogeneity of Variance Test Chisq. = 3.04
Probability = 0.55

Analysis of Variance

SOURCE	SS	MS	DF	F	p
GROUPS	0.250×10^3	62.42	4.	1.98	0.10
ERROR	0.293×10^4	31.57	93.		

In the probability matrix for the Scheffé multiple comparison of means the probability comparison given in the above table is substantiated. This information follows in Table 12.

Table 12. Probability Matrix for Scheffé Multiple Comparison of Means on Retention Test Scores of Four Variations of Programmed Presentation and a Normal Presentation

		GROUP				
		A	B	C	D	E
G	A	1.00	0.64	0,97	0.97	0.92
R	B	0.64	1.00	0.95	0.95	0.15
O	C	0.97	0.95	1.00	1.00	0.55
U	D	0.97	0.95	1.00	1.00	0.59
P	E	0.92	0.15	0.55	0.59	1.00

In time required the normal group took longer than any of the other groups, 105 minutes compared to an average time of 60.11 minutes for the audio-verbal, individually-paced group; 53.12 minutes for the printed-verbal, individually-paced group; and 38 minutes for the media-paced groups.

Such time differences must be considered an important consideration when designing learning materials. For example the normal group using a lecture and textbook reading approach took over twice as long as the media-paced groups using a programmed presentation and did not achieve as well as the other groups on either post-test or retention test. Such results may or may not be duplicated in other instructional settings. However, it would seem likely that somewhat similar results would be obtained. Reasons for this time difference might be as follows. One of the main reasons probably rests with the design of programmed instruction. In the program there were constant built in reviews and test situations. In normal lecture and textbook reading environments learners may be unsure of themselves on new material and waste time deciding what to study in detail. Further, the designer of a program can carefully eliminate all matter which does not promote the behavioral objectives decided on. A lecturer may wish to do the same, but often interesting but irrelevant material in terms of test performance may be interjected.

The most important consideration in relation to time, however, must be in relation to the comparative times taken by the four experimental groups. Since the factors involved in the time required by the normal group are difficult to delineate, and since it would be difficult to duplicate this normal group in other experiments, comparisons of such a group with programmed groups is questionable. The other groups can have the experimental conditions repeated and so these results are more important in an experimental sense. These differences between the programmed groups were discussed on pages 71-73.

A final dimension to the experiment was provided by a questionnaire which was administered at the same time as the post-test. This questionnaire was related to student opinion of different learning modes. Because of the numerous facets already incorporated in this research a limited time was available for preparation of the questionnaire and investigation of questionnaire technique. For this reason the questionnaire is handled as a matter of information primarily and is contained in Appendix E with a record of student responses. These student responses to different problems in the questionnaire were recorded only when three or more students responded in a similar manner to the same question.

Before answering the questionnaire the students read a brief description explaining the nature of the experimental presentation modes. In the questionnaire two items of particular interest deserve attention.

First of all students were asked in question two to state their personal preference regarding five possible learning modes; slide-tape in a group; slide-booklet in a group; slide-tape, individually paced; slide-booklet, individually-paced or a normal presentation such as they were used to. The responses relating to the best learning mode were as follows:

a.	slide-tape in a group	2
b.	slide-booklet in a group	1
c.	slide-tape individually paced	41
d.	slide-booklet individually paced	56
e.	normal presentation	11

It is interesting here that student opinion of the group presentation is so low, yet this was the presentation which was most efficient in use of student time with no noticeable difference in learning from the individually paced presentations. It would be helpful to educational planners if a group similar to the one in this study could be presented with a number of modes of instruction and then have a questionnaire. Students filling such a questionnaire would have a broader experience and their opinions should be more authoritative.

Another item of note in this questionnaire was the wish of students from all the groups to have work experiences related to their theoretical studies. Question number 4 in the questionnaire relates to specific elements which students wish to have as part of their learning environment. Only one student of those filling the questionnaire wished more theory. 71 felt they needed more live experiences with patient problems relating to the theory they study in class. Sixty-seven wanted more laboratory experiences. Sixty-six wished for more opportunity to study in small groups. Sixty-eight wished for more opportunity to use realistic models in the study of anatomy and physiology, and seventy-four wanted more use of pictures and films to help explain anatomy and physiology. Student opinion seems largely to suggest that in this particular environment the normal procedure depends too much on lecture and textbook reading in large groups, and students would like alterations in the directions indicated above.

Before moving to the section on Summary, Conclusions and Recommendations, mention will be made of how the results of the experiment compared with the non-statistical suggested hypotheses drawn from the review of the literature and mentioned at the beginning of this chapter.

The suggested hypothesis that individually-paced groups would take longer than media-paced groups, a typical result indicated in the review of the literature, was reaffirmed. However, in this experiment, higher test scores accompanying individual-pacing over group or media-pacing, due either to the mode of presentation or to the longer time periods usually required by individual-pacing, were not recorded. This result was true in spite of the fact that longer time periods were required for those in the individual-pacing mode than for media-paced groups. This result was probably due to the design of the program. There were constant built in reviews and test situations. Learners may be unsure of themselves on new material even though it is programmed and waste time developing a private review pattern which duplicates the review pattern of the program designer. Also learners may spend time overlearning which adds little to achievement. The exact reasons cannot, of course, be pinpointed here, but the results may indicate that a learning program which is designed to explain something like the ear as a system operating on logical physical principles and designed with built in review can be more efficient in use of learner time than a self-paced mode of instruction with no loss in average performance on an immediate post-test and delayed retention test.

The hypothesis that the slide-tape, individually-paced groups would average a longer mean time than the slide-booklet, individually-paced group was supported by the evidence. The former used 60.11 minutes, the latter 53.12 minutes. This indicated that in this program, which relied heavily on pictures, that printed-verbal instructions were more efficient in use of student time than audio-verbal accompaniment in a self-paced situation.

As a concluding note all groups using media required less time than the normal group. The two main reasons suggested are first that designing programs around specific behavioral objectives enables a designer to eliminate extraneous material more easily than a lecturer or writer of a textbook. Also as noted by Gropper (1966) learning from visuals may constitute an easier task than learning from verbal explanation. Thus, if we accept Gropper's conclusion, by relying heavily on visuals, making the learning task easier, one may enable students to learn in less time and thus increase instructional efficiency.

Chapter V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study involved several facets including development of a multi-media program based on behavioral objectives, as well as using this program in examination of pacing variables, presentation variables, and a study of time factors relating to these different presentations.

The program used in this experiment relied heavily on pictures as has been noted. The pictures were in slide form and were colour coded. It should be emphasized that no particular significance is attached to the slide format. This mode was chosen simply because it was the most economical and practical in this instance.

Visuals in slide form were thus a constant in the four main experimental groups. The two independent variables which were introduced were first a pacing variable with two variations, individual or self-pacing and group or media-pacing; and a second variable which involved presentation of verbal instructions. One variation of the verbal presentation utilized printed script in booklet form. Each page of the booklet had script related to a particular slide. The other verbal presentation had taped instructions in the voice of the regular instructor with a recorded beep to indicate a change of slides.

Experimental procedures in this study involved randomly assigning students to groups, administering a pre-test, an immediate post-test, a retention test and a questionnaire. The same instrument was used in all three testing situations. The average time taken by each group in the experiment was also recorded.

Data gained from the tests mentioned above were analyzed using an analysis of variance technique. Results on the pre-test showed no significant difference at the 0.05 level of probability so it was concluded that a true random sample had been achieved.

Also an analysis of variance on the post-test and retention test showed no significant difference at the 0.05 level of probability for the four main experimental groups.

However, when the normal group was included in the analysis a significant difference was found at the $p < 0.001$ level of probability on the post-test. The reasons for this difference are difficult to assess. Should further experimentation with carefully structured programs relying heavily on pictures continue to point out such differences, then instructors should begin to place more weight on such programs.

However, though results on the retention test still yielded normal group means lower than any of the other groups, the difference was not statistically significant at the 0.05 level.

One place in the program where differences between groups did exist, wherever it was possible for differences to occur, was in the time taken for completion of study. It was not possible to measure time differences in terms of statistical significance due to three of the groups having no internal variation. However, the differences appeared to be substantial. The two media-paced groups required thirty-eight minutes. The slide-booklet, individually-paced group required an average of 53.12 minutes and the slide-tape, individually-paced group 60.11 minutes. The group receiving normal instruction used 105 minutes.

CONCLUSIONS

The following conclusions were made based on the findings for the major hypotheses in this investigation.

The hypotheses apply strictly to the program developed for this study, but should also be applicable to similar programs promoting the same kinds of learning. Also strictly speaking, the experimental conclusions would apply only to the group on which the experiment was performed. In general terms, however, the results of the experiment should be generalizable to similar groups where mature learners have completed a high school program with a university level of achievement.

The conclusions reached in this experiment are as follows:

1. Achievement of first year nursing students learning the anatomy of the ear does not vary significantly on an immediate post-test for the following treatment groups: slide-tape, media-paced; slide-print, media-paced; slide-tape, individually-paced; and slide-print, individually-paced.
2. Achievement of first year nursing students on a delayed retention test does not vary significantly for the above stated treatment groups.
3. Utilization of time in a program on the anatomy of the ear does vary for the above presentation variables where time constancy is not part of the experimental

design. Based on the results of this experiment, time savings of from twenty-eight to thirty-three percent can be achieved by using a media-paced approach as opposed to a slide-tape, individually-paced and a slide-print, individually-paced approach respectively. Further, a slide-print, individually-paced approach can result in approximately sixteen percent savings in time over a slide-tape, individualized-pacing approach.

RECOMMENDATIONS

At a time when emphasis is being placed on individuals pacing their own learning activities, evidence of this and similar studies should provide material for rethinking some aspects of the question. For the conclusion reached here is that individual-pacing does not provide any statistically significant learning gains or even any perceptible learning gains over a media or group-pacing approach, while requiring substantially greater amounts of time.

This is not meant as a blanket condemnation of individualized-pacing procedures. It is, however, meant to question its value as a major learning technique for a class of post-secondary students such as a nursing class who face similar learning tasks. It might be helpful to repeat a quotation of Gropper's used earlier where he suggests that:

> It is unsound to assume that instruction is not individualized simply because presentation tempos are externally determined with no student allowed to adopt his own pace. The most trustworthy evidence that instruction has indeed been individualized comes from dependent measures describing group performance reflecting widespread learning effectiveness and efficiency. Gropper (1965:172)

Gropper's use of the term "widespread" would not, of course, apply to this single experiment, but this study does give information on "effectiveness" and "efficiency". The data in this study show that group-pacing is just as effective and more efficient in terms of time than is an individualized-pacing approach.

In the near future more may be learned about making individualized pacing a more efficient process. More may also be learned about its value to certain types of learners. But until more data is available on developing optimum levels of individual pacing it may be better for students to be involved in media-pacing procedures since this experiment indicates time savings for the media-pacing approach. The review of the literature indicates that this is a common finding.

A further question is suggested by this experiment. A great deal of energy has been put into developing audio accompaniments to learning programs. This study, however, suggests that audio is less efficient than print in terms of time as a means of providing verbal accompaniment to a learning program. This was shown when the audio-verbal, self-paced group took 60.11 minutes to complete the learning program, and the printed-verbal, self-paced group took 53.12 minutes. Also, in spite of the time differences, there were no significant differences in learning or even any noticeable differences. This conclusion agrees with that of Hartman (1961) who, after an extensive review of research in this area, suggested that most studies comparing print and audio present time advantages for the print mode for mature learners. Such evidence should not be ignored in developing a learning environment.

The evidence just referred to may, of course, be altered by new developments in compressed speech. Students in the audiovisual and curriculum development fields might find valuable areas of research in this field. Since compressed speech allows more words per minute on audio tape than is normally possible, the efficiency factor for print over audio tape may be altered. It may be true, however, that comprehension declines when noticeable increases in words per minute occur using an audible presentation.

With specific reference to the programmed materials developed for this study the following suggestions may be helpful to others who might wish to use it or similar programs. The materials which were developed might be used to duplicate the experiment as closely as possible with a similar population. Variations of the experiment could also be tried. A different population could be used, black and white pictures could be used instead of colour coding, or any of a number of other variations.

Also the materials for this study were designed primarily to be used as an integral part of study in anatomy, and instructors could use them as such. They might also use the materials as supplementary material to normal lecture procedures either in a group presentation or for individual study.

The compact nature of the materials also renders them suitable for review purposes. For such a function the built-in review portions of the program could be removed, the verbal text altered, and the materials further shortened. Other programs could also be developed for the same purpose. Geis and Anderson (1963:vii) indicated the value of this when they wrote:

> The problem of correlating nursing theory and practice becomes acute in some areas. A year or more may go by, for example, between the time the student learns a particular technique in class and practices it on a patient...Programs in these difficult areas can be kept constantly available and thus provide a new flexibility in nursing education. Geis and Anderson (1963:vii)

The study might also be used in a practical sense to help formulate patterns for learning environments. The patterns of presentation used in this experiment might be adopted by instructors, or they might be fitted into other procedures as a means of providing variety, or used as a base for further adaptation.

Though little importance was attached to the fact that diagrams were presented in slide form, instructors desiring a few copies of a program will find this a simple and economical way of producing visuals. Slides also allow for constant updating of visuals and revision of programs.

With increased research in the areas mentioned above needs to come a commitment from educational administrators and developers of curriculum to make continuing attempts at improved learning environments. Such individuals must come to feel that programming instruction is not an impossibility for the normal instructor. Particularly in an area such as anatomy where memorization of terms and development of concepts and principles serves as a basis for later work performance, programmed learning can be of great benefit. Human beings, even when they are professional instructors, are prone to error. Often an instructor changes formats of instruction because he is bored with the same presentation, even though that presentation may be most efficient in terms of learning. When repetitious but necessary aspects of instruction are programmed the instructor can be ready for more personal relationships and interaction with a class while still making certain that learners are confronted with necessary information.

Programs can be carefully developed, continually modified, and provide uniform instruction to pupils. Gagné (1968:12) says that:

> A subject like colloid chemistry, for example, can be described as a set of concepts (chemical structures) and relations among them. The number of concepts is, of course, a finite number; the number of relations they contain is also finite.

When a program is produced on a subject with such a finite set of concepts and relations between concepts, careful analysis can suggest ways of communicating these concepts and relations to learners in a way which provides understanding of the concepts and the systematic relationships between these concepts. Whereas essential links may be unintentionally omitted in a lecture, these will not be omitted in a mechanized program, and any errors or faults which appear can be permanently removed.

Also once a program is in existence students who forget rapidly may be cycled back through for remedial work. They may use programs identical to ones originally used, or modified programs for review purposes. Weiss and Green (1964:141) write that "programs offer the opportunity for students to review materials rapidly and efficiently through out their entire medical career as the occasion may arise."

This is not to suggest that mechanized programs can provide sufficient educational experiences for a student. The results of the questionnaire in Appendix C show that the students in this experiment desired an opportunity to interact with an instructor. Representatives from all groups in the experiment also felt a need for increased practical experience related to classroom theory. Provision for such experiences should also be included in a nursing curriculum.

Even in instances where programs become the predominant method of instruction it would probably be advisable to provide a variety of presentation techniques in an ideal structuring of a learning environment. One should, nevertheless, place greatest stress on those techniques which provide the greatest learning gains, are most efficient in terms of time for both student and instructor, are economical, and logistically feasible.

Following are some suggestions for utilization of information included in this study. If we accept, from the review of the literature, the value of a program which relies heavily on pictures or diagrams in presenting information as well as verbal instructions, the following would be recommended. Such a program seems to be most efficiently presented in terms of time by providing the verbal information in a print mode and using a media-pacing or group-pacing procedure. Using slides for visuals provides a good means of controlling pace as well as of presenting visuals to a group. Also a slide set can be easily altered to improve the program or to shorten it for review purposes. A program utilizing slides can be used with very large groups, small groups, or individuals with equal facility.

For any institution contemplating expanded use of locally produced programs a great many problems do seem to arise. Often instructors are not versed in programming techniques, or in production and use of visuals to accompany a program. Also instructors seldom have time for experimentation. Given a little time, however, such problems usually can solve themselves.

Probably one way of gradually moving into a system of programming would be to hire a person part-time on a contract basis who had some knowledge of programming and audiovisual techniques. Such an individual could begin by working with an interested instructor who was given some time for program development. One or more programs could be produced and used by one or more instructors. This would introduce staff to this technique. Should such programs provide advantages a full-time individual could be hired to aid in such development. In initial stages an institution may hire two or three individuals on a contract basis and thus become acquainted with different approaches to program development. Such an approach might also enable an institution to hire the individual most suited to its needs. Almost certainly such an individual should have progressed beyond the skill level of an audiovisual technician, and be versed in the educational application of new audiovisual techniques and in production of illustrated programs.

One must remember that experiments simply provide guidelines and it is only after a good deal of experience in an individual setting that final decisions can be made about the most efficient presentation of learning experiences in that setting.

All educational institutions should have an eye toward developing such experiences, for seldom can we say that we have reached an ultimate in our level of instruction. In the race for improvement we need to realize as well how seldom it is that we can simply look at learning innovations and immediately see the advantages and disadvantages of that innovation. But where the possibility of an advantage exists, there educational institutions should be examining and experimenting.

Jean Schweer (1968:vii) writes:

> Educators are reminded daily of the impact of the growing body of knowledge in such fields as the basic sciences, medicine and education. Much of the "knowledge explosion" touches the practice of nursing in two separate but interacting dimensions (1) application of an infinite variety of technological advances to direct patient care and (2) utilization of new teaching methods and devices.

It is not enough, however, simply to be reminded. Action should be taken in utilizing modern technology in education.

This study showed four approaches to a learning method not widely used. Experimental results seemed to indicate that this method had some advantages over a lecture and textbook presentation with similar goals. Similar techniques need to be tried on a wider scale.

Gilbert criticized the instructional field writing:

> For evidence of uncritical and precipitate development I have to go no further than to point out that there probably exist 100 different mechanical gadgets oddly called "teaching machines" and in sharp contrast maybe no more than two or three teaching programmes which in any way may be called complete. Gilbert (1960:477)

Since Gilbert's writing changes have occurred in programs as seen in Postlethwaite (1970) and Seedor (1963), but the need of the moment is still for development of learning programs which can be analyzed, improved and utilized in student learning rather than emphasizing instructional instruments. An anatomy instructor in nursing education with a camera and a commitment toward carefully developed learning experiences which can be tested analyzed and improved is taking a first step in this direction.

A second step can come only after a variety of programs are in widespread use through analysis of and experimentation with such programs.

This study can provide a pattern for program development and presentation formats. It also supplies some data concerning the comparative effectiveness of these formats in a particular setting. In conjunction with a number of other studies this experiment helps to fill out a picture regarding means of presenting programs to students. However, only when these formats are compared on a wider scale with programs in a variety of subject areas will it be possible to estimate the generalizability of the conclusions reached for even such a limited population as first year nursing students.

SUGGESTIONS FOR FURTHER RESEARCH

1. A basic finding in this experiment was that there was no significant difference in average learning scores among the four experimental groups on immediate post-test or on delayed retention test. However, there did exist considerable difference in average time taken for different treatment groups. The individually-paced, audio-verbal group took longer than the individually-paced, printed-verbal group. Media-paced groups were given the same time period. Since all groups achieved approximately the same results on post-test and retention-test it seems logical that more time would not have benefitted the media-paced groups since individually-paced groups who took all the time they wished did not do significantly better while spending a good deal of additional time to that spent by

the media-paced groups.

(a) Future research could take the program developed for this study, or a similar program, and do a variety of experiments on the media-paced presentations. Different rates of presentation on audio-verbal and printed-verbal modes should be used with the media-paced groups to ascertain which, if either or neither, presentation can be shortened substantially without loss in learning scores.

(b) Similar experimentation should be done using compressed speech techniques to shorten the presentation time of the taped presentation.

2. This experiment was based on a learning program on the anatomy of the ear. Future research should involve similar presentation techniques as those used in this experiment with several different programs. This would help to determine how generalizable are results such as those gained in the present study.

3. The materials for this study were developed locally using specific behavioral objectives. If more instructors decide to produce their own programs, it may be helpful to have specific production guidelines. A difficult area of

research to approach, yet one which could be highly beneficial, is research which would provide guidelines for program production.

4. If a number of similar programs to the one in this study could be used with nursing or similar classes a more reliable and carefully developed questionnaire could be given to students to ascertain their reactions to different learning modes. Since the learner is often thought of as the centre of learning or instructional activity, such a questionnaire, drawing as it would from learner experience and interest could be valuable in designing optimum learning environments.

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APPENDIX A

BEHAVIORAL OBJECTIVES

The list of behavioral objectives which follow are organized in the following manner. A general objective for the total program is given first of all. The rest of the objectives are listed as six major objectives with a number of more specific behavioral objectives listed beneath each of the major ones.

For purposes of convenience the major objectives will be capitalized and the specific behavioral objectives will appear in lower case. Both will be titled objectives.

GENERAL OBJECTIVE: Given time to cover these materials learners shall be able to explain basic phenomena concerning sound waves and sound pressure, and be able to describe the primary function of and interrelationship among the three major structures of the hearing mechanism. Given an iconic representation learners shall also be able to point to parts when named, or name parts when pointed to, as well as being able to describe the function of these individual parts, or to recognize the function of parts when these functions are described. Given an iconic representation of the entire ear or that part dealing with equilibrium, learners shall be able to name parts of the mechanism or equilibrium when those parts are pointed to, or point to parts when named, as well as being able to describe the functions of those parts.

MAJOR OBJECTIVE I

The learner shall be able to describe a molecule, the nature of molecules in a gaseous state, the results of molecular collisions, and the phenomena of sound pressure.

Objective 1. The learner shall be able to describe a molecule as being the smallest part into which a substance can be broken without changing its nature, and always existing in different states of motion.

Objective 2. The learner shall be able to describe the nature of molecules in a gaseous state as being one of free association with no fixed position and in constant collision with one another, imparting motion to other molecules in a manner similar to billiard balls on a pool table.

Objective 3. The learner shall be able to describe a sound wave as a regular motion of a number of molecules.

Objective 4. The learner shall be able to describe sound pressure as the force exerted by the molecules in sound waves.

MAJOR OBJECTIVE II: The learner shall be able to identify by name the three major parts of the hearing mechanism, describe their general function as a system, and their individual roles in this system.

Objective 1. The learner shall be able to define mechanical energy as that which exists whenever an object or particle which has weight is in motion, and relate this to moving molecules.

Objective 2. The learner shall be able to describe the major function of the hearing mechanism as being able to change mechanical energy due to sound waves into electrical energy for transmission to the brain.

Objective 3. The learner shall be able to identify by name and location the three major parts of the hearing mechanism and the eighth cranial nerve.

Objective 4. The learner shall be able to describe the function of the outer ear as being that of gathering moving air molecules and funnelling them in to make contact with a sensitive part of the middle ear.

Objective 5. The learner shall be able to describe the function of the middle ear as being that of a bridge transferring mechanical energy from outer ear to inner ear in a controlled manner.

Objective 6. The learner shall be able to describe the function of the inner ear as being that of changing mechanical energy to electrical energy.

Objective 7. The learner shall be able to describe the function of that part of the eighth cranial nerve which joints the curled part of the inner ear as being that of carrying electrical impulses to the brain.

<u>MAJOR OBJECTIVE III</u>: The learner shall be able to identify the parts of the outer ear by name and position, and identify the function of these parts. He shall also be able to identify by name the secretion of the auditory canal, cerumin, its purpose and possible danger.

Objective 1. The learner shall be able to identify by name and position, the auricle, the auditory canal, and material secreted by the auditory canal, cerumin.

Objective 2. The learner shall be able to describe the function of the auricle and the auditory canal as being that of a funnel collecting moving molecules and directing them to a sensitive part of the middle ear.

Objective 3. The learner shall be able to describe the curvature of the auditory canal as curving up and then down.

Objective 4. The learner shall be able to describe verbally or demonstrate on a live adult subject the proper method of readying the auditory canal for reception of medication, that of pulling up and back on the auricle.

The learner shall be able to describe or demonstrate that on an infant or young child the opposite is true and one must grasp the ear lobe and pull down and back.

MAJOR OBJECTIVE IV: The learner shall be able to describe the function of the middle ear, identify the major parts by name and position, as well as describe the position and influence of the mastoid cells.

Objective 1. The learner shall be able to describe the function of the middle ear as being that of transmitting mechanical energy due to moving air molecules from the outer ear to the inner ear.

Objective 2. The learner shall be able to identify a membrane as a thin flexible layer of tissue.

Objective 3. The learner shall be able to identify the ear drum tympanic membrane by both these names and by position.

Objective 4. The learner shall be able to describe the function of the ear drum as being a membrane extremely sensitive to sound pressure, and moving rapidly in time with fluctuating sound pressures due to the moving molecules of sound waves.

Objective 5. The learner shall be able to describe the function of the middle ear bones as being the transmission of mechanical energy from the ear drum to the inner ear with greater force and while moving a lesser distance.

Objective 6. The learner shall be able to designate the three bones of the middle ear by name and position using both common and scientific names, Malleus (hammer), Incus (anvil), and Stapes (stirrup).

Objective 7. The learner shall be able to identify the eustachian tube by name and position and describe its function as being that of equalizing pressure between the auditory canal and middle ear cavity.

Objective 8. The learner shall be able to point out the position of the mastoid cells, identify them by name and describe the possible danger which they provide due to harbouring infection and providing a path for infection to spread.

MAJOR OBJECTIVE V: The learner shall be able to differentiate between the auditory part of the inner ear and the part related to balance, describe the function of the auditory part of the inner ear, and be able to identify by name and position the elements and describe the function of these elements.

Objective 1. The learner shall be able to describe the function of the inner ear as being the final site at which mechanical energy is changed to electrical energy.

Objective 2. The learner shall be able to designate by name and position the osseous and membranous labyrinths of the inner ear, and state that both are fluid filled.

Objective 3. The learner shall be able to identify the oval window by name and position and describe the function as being to transfer mechanical energy from the middle ear in to the inner ear.

Objective 4. The learner shall be able to identify the cochlea by name and position.

Objective 5. The learner shall be able to describe the cochlea as a hollow body with two chambers, one, part of the osseous labyrinth, and the other, part of the membranous labyrinth; and that they are together rolled up in the shape of a snail.

Objective 6. The learner shall be able to identify by name and position the two membrane covered openings of the cochlea which open into the middle ear cavity, the oval window and the round window.

Objective 7. The student shall be able to describe the function of the oval window as creating pressure on the fluid of the membranous labyrinth, and the function of the round window as dissipating that pressure.

Objective 8. The learner shall be able to identify the vestibular and tympanic canals by name and state that the oval window opens into the vestibular canal, and the round window into the tympanic canal.

Objective 9. The learner shall be able to designate the item separating the vestibular and tympanic canals as part of the membranous labyrinth.

Objective 10. The learner shall be able to designate the portion of the membranous labyrinth as it appears in the cochlea as the cochlear duct.

Objective 11. The learner shall be able to identify by name the fluid of the membranous labyrinth, or cochlear duct, as endolymph, and the fluid of the osseous labyrinth as perilymph.

Objective 12. The learner shall be able to identify by name and position two divisions of the cochlear duct, the Reissner's membrane and the basilar membrane.

Objective 13. The learner shall be able to identify by name and position the Organ of Corti.

Objective 14. The learner shall be able to identify by name and position the parts of the Organ of Corti, hair cells, tectorial membrane, and nerve fibers.

Objective 15. The learner shall be able to state that it is bending and twisting of the hair cells of the Organ of Corti which produces electric current that is interpreted as sound in the brain.

Objective 16. The learner shall be able to state that twisting of the hair cells is due to the tips being caught in the tectorial membrane, and the base of the hair cells being imbedded in the basilar membrane, and that motion of the middle ear fluid causes these membranes to move in opposite directions.

Objective 17. The learner shall be able to state that movement of the oval window produces movement in the perilymph which is passed to the endolymph through Reissner's membrane. Movement of the endolymph causes vibration of the basilar membrane and twisting of the hairs of the hair cells.

Objective 18. The learner shall be able to identify by name and position the eighth cranial nerve, and that part of it designated as the cochlear nerve.

Objective 19. The learner shall be able to state that electrical signals produced by the hair cells travel through the cochlear nerve to the eighth cranial nerve to the brain where they are interpreted as sound.

MAJOR OBJECTIVE VI: The learner shall be able to identify that part of the inner ear used for equilibrium and identify by name and position the major elements responsible for equilibrium.

Objective 1. The learner shall be able to state that the actual mechanism of equilibrium is found in part of the membranous labyrinth even as the apparatus for hearing was found in the membranous labyrinth of the cochlea.

Objective 2. The learner shall be able to identify by name and position the semicircular canals, the ampulla of the semicircular canals, and the utricle.

Objective 3. The learner shall be able to identify the ampulla and the utricle as containing the apparatus of equilibrium.

Objective 4. The learner shall be able to state that the actual mechanism of equilibrium is a number of hair cells similar to the hair cells of the Organ of Corti.

Objective 5. The learner shall be able to describe a generalized structure of the apparatus of equilibrium as consisting of one or more hair cells with hairs which protrude into a gelatinous membrane containing otoliths, tiny bits of calcium carbonate.

Objective 6. The learner shall be able to state that movement of the head causes the otoliths to move due to gravitational attraction and cause movement of the hair cells which produces an elective current.

Objective 7. The learner shall be able to identify the mechanism of equilibrium within the utricle as the macula, and within the ampulla as the crista ampullaris.

Objective 8. The learner shall be able to state that twisting of the hair cells produces an electric current which passes through nerve fibers to a branch of the eighth cranial nerve and from there to the brain where the message is interpreted.

Objective 9. The learner shall be able to state that the sense of hearing and equilibrium is due to the interpretive mechanism of the brain and not to the nature of signals generated by the respective hair cells. In connection the learner shall be able to state that sometimes signals from one centre such as sight do pass over to the hearing centre with resultant confusion in the interpretive centre in the brain responsible for sound.

APPENDIX B

The script which includes the verbal information used in the program on which this experiment was based as well as a description of each visual follows. At each point where a xxx appears in the script, a new page in the original program booklet is indicated, as well as signalling movement to a new slide.

During this time of individualized instruction you should attempt to work as efficiently as possible. Each page of the instruction booklet contains instructions relating to one slide. Each time you complete a page of the instruction booklet you should advance the slide projector unless specific instructions are given to the contrary.

1. Title slide THE EAR	Proceed now by making sure that your projector is turned on and advance to the first visual which should be a title slide of the ear. Leaving this visual on turn to the next page of the manual. xxx
2. Package of salt, with salt spilled beside it.	We are going to begin our discussion with something seemingly far removed from the ear. This is a consideration of molecules, for you see without molecules you wouldn't hear. Now you probably know a great deal about molecules, but let's take a little review. xxx
3. Representation of sodium and chlorine molecule.	For example salt is made up of molecules which contain in turn a molecule of sodium and a molecule of chlorine. xxx
4. Representation of salt molecule	If you were to take a crystal of salt and start dividing it into pieces, you would finally reach the place where by dividing it further you would no longer have salt but sodium and chlorine. Let's suppose the white ball is sodium and the black one is chlorine. xxx

5. Salt molecule	The sodium and chlorine are now tied together. When they are so tied we have a molecule of salt. If it is divided further we no longer have salt. Thus it is plain that a molecule of a substance is the smallest part that a substance can be divided into and still have the same properties it started out with. There is one other thing about molecules, however, we cannot see here. Molecules are always in motion. The difference between a solid, a liquid, and a gas is simply how much the molecules of a substance are moving. The air around us is a gas, and in a gas molecules move a lot. xxx
6. Pool table full of moving balls	We might compare molecules of a gas with the balls on a pool table. If these balls moved all the time the comparison would be closer. Imagine a pool table full of moving balls which still could have their direction changed. xxx
7. Pool ball and cue	We could make one of the balls move as we wished, or xxx
7. Cue length-wise moving several balls.	we could take an item such as the one shown and cause several balls to move together. To make <u>molecules</u> move in this way we need a vibrating object. xxx
8. Drum	Drum heads vibrate when they are struck, pushing out molecules of air from their surfaces, just as a pool cue pushes a ball or balls out in front of it. xxx

9. Pool table

Now molecules do not weigh as much as pool balls but they do have weight. Thus a molecule striking a surface exerts some pressure. Many molecules striking a surface together exert more pressure, just as many moving pool balls would exert more pressure than would one. Imagine that the end of a pool table were made of thin rubber. When one ball hits it, it would move a little. Several balls would make it move more. Any vibrating object pushes thousands of molecules out from its surface. Such a motion of many molecules moving out from a vibrating surface is called a sound wave. The pressure such a sound wave exerts when it strikes a surface is called sound pressure.

Now mechanical energy is a property of anything which moves and has weight. A moving ball has mechanical energy. So does a moving molecule.

xxx

10. Generalized drawing of ear

Here we have a generalized drawing of the ear emphasizing its function. We have learned that the greater the number of molecules striking a surface at one time the greater is the pressure on that surface. One part of the ear acts as a funnel gathering moving air molecules and directing them to strike a membrane we call the ear drum. When the ear drum moves it pushes against a bridge of bones here represented as a blue wedge. Motion is passed through these bones and causes motion in a fluid which eventually causes an electric current to be produced. This electric current is interpreted by the brain as sound.

xxx

11. Gen. drawing of ear labelled, outer ear, middle ear, inner ear, and nerve.	If we were to label this diagram as its parts relate to hearing we would have: outer ear, a funnel collecting moving molecules so they can exert their energy at one particular point, the ear drum. The middle ear transfers motion from the outer ear to the inner ear, and in the inner ear mechanical energy due to the initial moving air molecules is changed to electrical energy. xxx
12. Ear, labelled as above	Here are the same labels on an actual representation of the ear. Before we examine these parts in detail we will quickly survey their major aspects. xxx
13. Ear, outer ear colour coded.	The outer ear is the part which can be touched and observed from the outside. As mentioned it serves as a funnel collecting sound waves and directing them in to the membrane which closes off the canal part of the outer ear. xxx
14. Ear, middle ear colour coded.	The membrane just mentioned, the ear drum, will be regarded as part of the middle ear. Energy arrives at the ear drum in the form of mechanical energy due to moving air molecules. This energy varies tremendously, from a quiet whisper to the scream of a jet engine. The middle ear bones are designed to carry the energy due to the whisper to the inner ear in a recognizable way, and to stop large vibrations of the membrane from causing damage to the inner ear. xxx

15. Ear, inner ear color coded.	The bridge of bones referred to is fastened to a membrane of the inner ear. When these bones move this membrane also moves. Inside the inner ear are fluids which are thus put into motion. This motion moves certain elements and presto mechanical energy becomes electrical energy. But electrical energy has no meaning by itself. It is only when this electrical energy reaches the brain that it becomes interpreted as sound and you are looking at the nerve, here colored green, that starts the signal on its way. xxx
16. CU of outer ear, labelled OUTER EAR	Even when examining the ear in detail, a brief look at the outer ear is nearly all we need to take. We are already acquainted with its function which is to increase the sound pressure on the membrane or ear drum which is the first part of the middle ear. xxx
17. CU of outer ear with labels, auricle, auditory canal, cerumin, ear lobe and helix	However, as a nurse you will need to know certain terms. After all there are handsome doctors around whom you will wish to impress with your brains as well as with your beauty. To do this you may need to know that the outer part of the ear is called the auricle, the top of the ear is the helix, the bottom projection is the ear lobe. The canal leading in from the aurical is the auditory canal. Modified sweat glands in the auditory canal produce a wax-like substance known to most of the world as wax, but professionally known to you as cerumin. Its purpose is to lubricate and to prevent entrance of foreign matter into the auditory canal. This cerumin can also build up, grow hard, and obstruct the auditory canal.

Often medication must be applied to the auditory canal. As you see in the diagram the canal curves up and then down. If you grasp the helix of the auricle firmly and pull up and back medication will run in smoothly. Do it on yourself right now. Notice that it would be a simple matter to pull too hard. Many a patient has started hiding under hospital beds because a nurse pulled his helix too hard. An oppo ite technique must be used for children. Here one must grasp the ear lobe and pull down and back before administering medication.
xxx

18. CU of outer ear, lines to parts named above with letter a, b, c, d, and e.

Now let's review the outer ear. First think of the purpose.

I hope you remembered that it was to increase the sound pressure on the middle ear membrane, or to carry mechanical energy due to moving air molecules to this location. And the parts in order are helix, auricle, ear lobe, cerumin and auditory canal.
xxx

19. CU of middle ear, labelled MIDDLE EAR

Now we can move to the middle ear. It is interesting to note how the more complex parts of the ear are increasingly protected. For example the middle ear is protected by being well inside the skull, and also protected by the curve in the auditory canal.
xxx

20. CU of middle ear, labelled membrane, middle ear bones or ossicles.

It would seem that the only reason we have the middle ear is to transmit mechanical energy from the outer ear to the inner ear in a controlled manner. Notice, however, that the middle ear bones, or ossicles, are supported by ligaments. These ligaments control the amount of movement possible to the ossicles. This prevents their moving too far and putting a hole in the inner ear. Also the ossicles work together like a lever. The result is that motion on the membrane of the inner ear is reduced; in other words the inner ear membrane moves a lesser distance than the outer ear membrane or ear drum. But a force applied to the ear drum becomes larger on the inner ear membrane. For example a pressure of one pound per square inch on the ear drum might become ten pounds per square inch on the inner ear membrane.

Now take a close look at the terms applied to parts of the middle ear mechanism. The membrane beginning the middle ear is called in common terms the ear drum and in scientific terms the tympanic membrane. Notice that the ossicles are composed of three bones commonly called the hammer, anvil and stirrup. Scientifically they are called the malleus, incus, and stapes. Go over these terms in your mind for a few moments.
xxx

21. CU of middle ear. Eustachian tube labelled and arrows showing direction of air pressure on the ear drum.

There is another important part connected with hearing in the middle ear. We are all acquainted with the fact that air pressure is usually somewhere between 14 and 15 pounds per square inch. However this pressure changes which means the pressure outside the eardrum changes. Now if

pressure outside the ear were to increase above pressure inside then the ear drum would be stretched in, and in a stretched position it would not be sensitive to varying sound pressures produced by sound waves. Therefore a mechanism exists to keep pressure the same on both sides. This is the eustachian tube which opens in the throat. Air coming into the throat through the nostrils or open mouth travels up the eustachian tube. This maintains an equal pressure on both sides of the ear drum.
xxx

22. CU of middle ear, mastoid cells labelled.

The last item we refer to is here because of location and not because of a direct link with hearing. These are the mastoid cells. They exist as pockets in the bones around the middle ear. Often infection starts here, and these cells offer a path for infection to spread.
xxx

23. CU of middle ear with lines to each part named and letters a, b, c, d, e, f, and g.

As a review of the middle ear first try to remember the function...In your mind you should have been going over something like this. It carries mechanical energy from outer ear to inner ear in a controlled way in order to protect the inner ear and amplify minute vibrations of the ear drum.

Name the parts designated here.

First of all you should have recognized the eustachian tube, then the three bones which are together termed the ossicles, and separately the hammer, anvil and stirrup. Then there are the mastoid cells, and unlabelled are the ligaments holding the ossicles and the tympanic membrane.

24. CU of inner ear, labelled INNER EAR	We have finally gotten the mechanical energy which started as a number of air molecules moving together through the tympanic membrane and the ossicles to the inner ear. xxx
25. CU of inner ear, cochlea colour coded	However the inner ear is not just meant for hearing. It also provides us with a sense of balance. The lower part shaped like a snail provides for hearing. The upper part with the semi-circular canals is responsible for balance. Right now we wish to centre attention on the lower, snail shaped part of the inner ear. This part of the inner ear is called the cochlea. The part we are looking at now represents the body outside part of the cochlea. xxx
26. CU of inner ear showing membranous and osseous labyrinths.	Let's look inside this bony covering. Inside we find a membranous tunnel which follows the same twisting path as the bony exterior. These twists and turns have led anatomists to call these structures labyrinths even as a twisting tunnel is called a labyrinth. Since osseous and bony mean the same thing, the bony covering of the inner ear is called the osseous labyrinth, and the soft inner tunnel is called the membranous labyrinth. Both of these tunnels are filled with fluid. Actually the fluid of the osseous labyrinth supports and protects the soft inner membranous labyrinth. xxx
27. CU of inner ear, labelled osseous labyrinth, membranous labyrinth, perilymph, and endolymph.	The fluid of the osseous labyrinth is the perilymph. Peri- of course means around or outside as in perimeter. Endo- means inside; therefore the fluid of the membranous labyrinth is the endolymph. xxx

28. CU of inner ear with cochlea and oval window labelled	Now let us return to the matter of energy transmission. The ossicles deliver their energy to a membrane found in the osseous labyrinth. This is called the oval window. As the oval window moves in and out pressure is applied to fluid inside, the perilymph. This pressure causes motion in the fluid of the cochlea, the snail shaped part of the inner ear. xxx
29. XS of cochlea showing walls of membranous labyrinth	If we look at the cochlea in cross section we can see that the walls of the hollow membranous labyrinth divide the osseous labyrinth into an upper and lower part. xxx
30. CU of inner ear with oval window and round window labelled.	Thus the coloured portion we see here extends across the osseous labyrinth from one side to the other, even though it does not extend from top to bottom. If one looks carefully at the centre of the coil of the cochlea one can see that the end of the membranous labyrinth does not touch the osseous labyrinth. Thus when pressure is applied at the oval window fluid moves on top of the membranous labyrinth around the end and back beneath it. A second membrane, the round window moves in and out with this motion. Excess mechanical energy is thus dissipated through the round window and out into the middle ear cavity. xxx
31. Unrolled cochlea, labels for round window, perilymph and endolymph.	A look at the cochlea as though it were unrolled may help illustrate what happens. Pressure is applied at the oval window. This causes motion in the perilymph which travels through the cochlea until finally the energy is dissipated at the round window. Some

motion is also transmitted from the perilymph to the endolymph in the membranous labyrinth, or cochlear duct, which is a highly significant fact.
xxx

32. Unrolled cochlea labelled cochlear duct, tympanic canal, and vestibular canal.	The upper canal of the osseous labyrinth which the oval window opens into is called the vestibular canal. The lower canal is the tympanic canal. The part of the membranous labyrinth which separates these two parts is the cochlear duct. It is in this cochlear duct that mechanical energy finally becomes electrical energy. xxx
33. Unrolled cochlea labelled vestibular membrane and basilar membrane.	Because the membranes which separate the cochlear duct from the vestibular canal and the tympanic canal serve different purposes they are given distinguishing names, the vestibular membrane and the basilar membrane. Let's look at a cross section showing these two membranes. xxx
34. X-sect. of cochlea vestibular membrane and basilar membrane labelled.	The upper membrane is called the vestibular membrane, and the bottom one which serves as a base for the organ ultimately responsible for changing mechanical energy to electrical energy is the basilar membrane. xxx
35. X-sect. of cochlea, Organ of Corti labelled.	On this basilar membrane is the Organ of Corti. xxx

36. X-sect. of cochlea with hair cells, tectorial membrane and basilar membrane labelled.

Fundamentally the Organ of Corti is simply a number of cells based on the basilar membrane with hair tips caught in what is termed the tectorial membrane. Motion of the endolymph, the fluid of the cochlear duct, causes the basilar membrane and tectorial membrane to move. When they move, they move in opposite directions twisting the hair cells. This twisting creates an electric current.
xxx

37. X-sect. of cochlea with oval window, perilymph, vestibular membrane, endolymph, basilar membrane, tectorial membrane and hair cells labelled.

Let's follow motion from the time it arrives at the oval window until it finally becomes electrical energy. You know that the motion starts when movement of the oval window is transmitted to it by the ossicles. This motion is passed to the perilymph and this produces motion in the vestibular membrane. When the vestibular membrane moves the endolymph moves and the endolymph causes motion in the basilar membrane and in the tectorial membrane. Since these two membranes move in opposite directions and the hair cells are fastened to both, this puts the hair cells in a bind. The result is the twisting of the hairs and electrical energy.
xxx

38. Nerve fibers going to brain with labels, nerve fibers, cochlear nerve, eighth cranial nerve and hearing centre.

Of course electrical energy means nothing to hair cells, so they pass this energy along to nerve fibers. These nerve fibers join to form the cochlear nerve which again joins a larger nerve, the eighth cranial nerve.

39. As before no labels	As represented here nerve fibers pass to both sides of the brain. Injury to one side of the brain thus does not cause complete deafness. xxx
40. Brain, broad-side, hearing centre colored.	This side view gives some idea of the proportion of the brain given to interpretation of electrical signals from the ear. It is plain that nature considers hearing important. xxx
41. X-sect. of inner ear	As you have seen the inner ear is a fairly complex mechanism, even though it is based on the relatively simple principle that bending a hair produces electricity. Many record players work on the same principle. The only difference is that the ear goes to much greater lengths to bend a hair than does a record player. Now take a moment to review what you remember of the workings of the inner ear. xxx
42. CU of cochlea with cochlea, membranous labyrinth, and osseous labyrinth labelled	First let's review some of the parts. The two basic elements are the osseous labyrinth and the membranous labyrinth. xxx
43. CU of cochlea with lines and letters to oval window, vestibular canal, cochlear duct, and round window.	Try to put names to the parts designated by this diagram. xxx
44. as above with labels.	Study this slide.

Two membranes connect the inner ear with the middle ear cavity. They are the oval window and the round window. The oval window is a place for mechanical energy to enter. The round window is a place for mechanical energy to escape. The vestibular canal, tympanic canal and cochlear duct hold fluids. They also direct motion in these fluids.
xxx

45. X-sect. of cochlea with Organ of Corti, hair cells, tectorial membrane, nerve fibers, and cochlear nerve lettered.	Last of all there is the little organ that finally changes mechanical energy to electrical energy and the parts that make it up. xxx
46. As above with labels.	This organ is the Organ of Corti based on the basilar membrane and made up of hair cells, a tectorial membrane and nerve fibers to carry electrical energy to the cochlear nerve and from there to the brain. xxx
46. CU of inner ear with equilibrium centre color coded.	In beginning the discussion of the inner ear we mentioned that the inner ear fulfilled two functions. One was hearing the other was to provide a sense of equilibrium or balance. It is in the semicircular canals that we find the apparatus for providing a sense of equilibrium, a sense of position relative to the pull of gravity. xxx
47. CU of equilibrium centre, osseous and membranous labyrinths labelled.	As in that part of the inner ear responsible for hearing it is in the membranous labyrinth that the mechanism for equilibrium is found. Basically the mechanism is found in the bulges at the base of the semicircular canals. xxx

48. Generalized diagram, hair cells, otoliths, and gelatinous membrane labelled.

This mechanism again is based on the fact that bending a hair can produce an electric current, just as we found in the Organ of Corti. This is an imaginary construction of what this mechanism might look like. We are told that hair cells extend into a gelatinous membrane containing bits of calcium carbonate called otoliths or ear stones. When the head moves these ear stones pull on the hairs twisting them, and you know what that does. Also nerve fibers lead from the hair cells to the brain. These fibers also become part of the eighth cranial nerve, as did fibers leaving the cochlea.

xxx

49. CU of whole hearing mechanism.

You should now have a rather complete picture of the parts and principles that give us our sense of hearing. Before we take a quick review, take a five minute break. First of all turn off the projector, so that when you return you will be looking at the diagram now visible.

REVIEW

Welcome back. You should be looking at the same picture you were looking at when you left. If you aren't looking at it maybe you need to turn your projector on. The picture is one of the whole ear.

xxx

50. CU of generalized mechanism of equilibrium. Letters a, b, c, and d to designate hair cells, gelatinous membrane, otoliths, and nerve fibers.	We will first of all review the mechanism of equilibrium. This diagram simply shows a functional relationship between the elements involved in equilibrium. Otoliths in the gelatinous membrane move when the head moves; they put pressure on the hair cells which twist and produce an electric current which is carried by nerves to a centre of equilibrium in the brain. The mechanism of equilibrium is found in the bulges at the base of the semi-circular canals. xxx
51. CU of entire ear.	The mechanism of hearing exists for one purpose, that is to produce electrical signals from the mechanical energy found in moving air molecules. Do you remember the three major divisions of the ear, and the primary function of each? xxx
52. Ear with labels for outer ear, middle ear, inner ear, and acoustic nerve.	There is first the outer ear meant to gather moving molecules and direct them in to the ear drum of the middle ear. The outer ear increases sound pressure on the ear drum by causing a greater number of moving molecules to strike it. The middle ear simply transfers mechanical energy from outer ear to inner, and the inner ear takes this mechanical energy and transforms it into electrical energy. xxx
53. CU of outer ear with letters a, b, c, d and e representing auricle, helix, ear lobe, auditory canal and cerumin.	There are only a few parts to the outer ear, and these are all rugged parts since they could be easily damaged. Name the parts pointed to here. xxx

54. As above with with labels.	Here are the parts named for you. xxx
55. CU of middle ear lines and letters to ossicles, hammer (malleus) anvil, (incus), stirrup (stapes), tympanic membrane.	Name the parts of the middle ear pointed to here. One part not labelled is the tympanic membrane or ear drum. The other parts in order are the eustachian tube, the ossicles or hammer, anvil, and stirrup scientifically known as the malleus, incus, and stapes. Last of all are the sometimes trouble causing mastoid cells. By now I have so much faith in you that I am sure that you remembered these parts. Possibly you forgot one of the scientific terms for one of the ossicles, but that can be forgiven. If you forgot two, well, let's not consider that possibility. xxx
56. CU of inner ear, lines and letters to oval and round windows and cochlea.	Now we come to the complicated part, the inner ear. Pointed to here are the membranes which open from the inner ear into the middle ear cavity, and the coiled structure in which are found the cells responsible for hearing. xxx
57. As above with labels.	Of course the membrane to which the stapes is attached is the oval window, the other membrane is the round window, and the snail-shaped object is the cochlea. xxx
58. CU of cochlea with lines and letters to membranous and osseous labyrinths and fluids.	If we could break up the fine bone constituting part of the cochlea and look inside we would see that a soft winding tunnel occurs inside the outer bony one, and that both are filled with fluid. xxx

The membranous tunnel is the membranous labyrinth. It is filled with endolymph. The bony tunnel is the osseous labyrinth, since osseous means bony. It is filled with perilymph.
xxx

59. As above with parts labelled.

Three membranes can be found related to the membranous labyrinth of the cochlea.
xxx

The vestibular membrane separates the upper part of the cochlear duct from the perilymph; the basilar membrane separates the lower part of the cochlear duct from the perilymph, and the tectorial membrane is inside the membranous labyrinth.
xxx

60. X-sect. of cochlea with lines to vestibular canal, tympanic canal, and cochlear duct.

Since the cochlea is for practical purposes divided into three divisions each has a name. One we have just mentioned.
xxx

61. As above with labels.

The divisions containing perilymph are called the vestibular canal, and the tympanic canal. The division with endolymph is the cochlear duct.
xxx

61. X-sect. of cochlea with lines to Organ of Corti, hair cells, tectorial membrane, and nerve fibers.

Then we come again to that part where we no longer pass on motion, or mechanical energy from one place to another, but where mechanical energy becomes electrical energy. Name the parts.
xxx

62. As above with labels.

This part is the Organ of Corti, the core of the whole hearing apparatus. xxx

You have now completed instruction on the ear. I am proud of you for your tenacity. Now for a short quiz so that both of us may discover the success of the procedure you have just gone through. Ask you instructor for further information.

Thank you for your careful study. Good luck and goodby for now.

APPENDIX C

QUESTIONNAIRE

At the same time that the retention test was administered, a questionnaire was also given to the students. With the questionnaire was an explanation of the experimental treatments used in this study. Questions related directly to the experiment as well as to instructional techniques in general. Following are the instructions as they were given to the students and a copy of the questionnaire with a record of the students' responses according to group with a total of all responses. Only where three or more responses were made is a record noted.

A page of instructions preceded the questionnaire. This also summarized treatment modes so students would have a basis on which to compare the treatments with their own.

You were recently part of an experiment in which instruction on the ear was presented in five different ways. There were four relatively new ways of presentation and one normal presentation. In the normal presentation students could write and take notes while in the other presentations students observed only, without writing. All the students had the same test immediately after their treatments. In the presentation using the newer procedures the materials were designed with built in repetition and review so that the necessity of going back over materials in review was minimized.

Group A: received instruction in which students observed slides and listened to a tape which provided verbal instructions. They received this instruction in a group and had opportunity to go through the materials once only. Slide-tape group-paced.

Group B: This group also looked at labelled slides on the ear but instead of listening to a tape they read a printed booklet which had the same verbal information presented on the tape. They also watched in a group with no opportunity to return to part of materials. Slide-print group-paced.

Group C: This group received information through slides and tape as well as did Group A, but this group went through the information individually and could review and take any amount of time they wished. Slide-tape individually-paced.

Group D: This group received information through slides and printed booklet as did group B but each person in the group went through the materials individually taking the amount of time each thought to be necessary for repetition and review. Slide-print individually-paced.

Group E: received instruction through a normal procedure of lecture and use of the overhead projector to present diagrams of the ear.

1. In a recent experiment you were in a group which received instruction in one of five ways. Circle the letter relating to the type of instruction which you received:
   a. slide-tape in a group
   b. slide-booklet in a group
   c. slide-tape, individually paced
   d. slide-booklet, individually paced
   e. normal instruction (lecture mainly)

2. Indicate the presentation which you feel would be best for learning purposes.
   a. Slide-tape in a group
      A = 2 B = 0 C = 0 D = 0 E = 0

      Total = 2

   b. Slide-booklet in a group
      A = 0 B = 0 C = 0 D = 0 E = 1

      Total = 1

   c. Slide-tape individually paced
      A = 10 B = 6 C = 15 D = 5 E = 5

      Total = 41

   d. Slide-booklet individually paced
      A = 7 B = 11 C = 4 D = 15 E = 19

      Total = 56

   e. Normal instruction
      A = 0 B = 3 C = 2 D = 0 E = 6

      Total = 11

3. Circle the presentation which you feel would be least suitable for learning.
   a. Slide-tape in a group
      A = 3 B = 10 C = 10 D = 14 E = 18

      Total = 43

b. Slide-booklet in a group
A = 6 B = 5 C = 5 D = 4 E = 6

Total = 26

c. Slide-tape individually paced
A = 0 B = 0 C = 0 D = 0 E = 2

Total = 2

d. Slide-booklet individually paced
A = 2 B = 0 C = 0 D = 0 E = 2

Total = 4

e. Normal instruction
A = 9 B = 5 C = 4 D = 3 E = 4

Total = 25

4. Circle as many of the following statements as are applicable.
   a. I am happy with instruction as it has been handled in my first year of study in nursing education.
   A = 2 B = 6 C = 1 D = 1 E = 7

   b. I feel that instruction would be improved by adding the following type of experiences:
      i. more real live experiences with patient problems relating to the theory we study in class.
      A = 18 B = 15 C = 13 D = 15 E = 20

      Total = 71

      ii. more emphasis on theory in a class room setting
      C = 1 for a total of 1

      iii. more laboratory experiences
      A = 14 B = 12 C = 10 D = 12 E = 19

      Total = 67

iv. more opportunity to study individually with materials especially prepared for the unit we are studying.

A = 12 B = 9 C = 8 D = 8 E = 13

Total = 55

v. more opportunity to study in small groups.

A = 16 B = 14 C = 7 D = 11 E = 18

Total = 66

vi. more opportunity to ask questions of our instructor relating to problems which are difficult to settle by reading and individual study.

A = 6 B = 6 C = 4 D = 7 E = 9

Total = 32

vii. more use of pictures and films to help explain anatomy and physiology.

A = 13 B = 14 C = 14 D = 14 E = 19

Total = 74

viii. more opportunity to use realistic models in the study of anatomy and physiology.

A = 12 B = 11 C = 13 D = 11 E = 21

Total = 68

In number 4 students were asked to "add other items which they felt would lead to improvement in instruction in addition to the ones listed." Using three similar responses as a criterion level for inclusion in this discussion, the following items were used.

Material is normally covered too quickly.

A = 2 C = 1 E = 1 Total = 4

It would be helpful to study in smaller groups than in the normal classes.

A = 2 D = 3 Total = 5

Greater use should be made of guest lecturers.
A = 2 C = 1 E = 1 Total = 4

Present classes tend to be too long.
A = 2 C = 1 E = 1 Total = 4

5. What do you feel is the chief problem or problems with the type of treatment you used in the experiment. (In the following improvised responses a record is noted where three or more students had similar responses)

Group A

..Very little opportunity to review or ask questions about things which I did not fully understand. 7

..Even though I had an opportunity to review it would have helped to be able to ask questions of an instructor. 10

..Labelling of pictures was difficult to read. 3

Group B

..Very little opportunity to review or ask questions about things which I did not fully understand. 8

..Even though I had an opportunity to review it would have helped to be able to ask questions of an instructor. 4

..Additional criticism pointed out that pacing was too fast. 10

Group C

..Even though I had an opportunity to review it would have helped to be able to ask questions of an instructor. 10

Group D

..Very little opportunity to review or ask questions about things which I did not fully understand. 3

..Even though I had an opportunity to review it would have helped to be able to ask questions of an instructor. 6

Group E

..Very little opportunity to review or ask questions about things which I did not fully understand. 10

..The material was boring 6

..Labelling of pictures was difficult to read. 6

6. What if anything could be done to help solve the problems you mentioned above. (improvised responses)

   a. Have an instructor available to answer questions.
   A = 11 B = 3 C = 7 D = 3 Total = 24

   b. Individual pacing.
   A = 4 B = 12 Total = 16

   c. Take longer on each section of anatomy.
   E = 3

7. Comment in any way you wish on methods of instruction. Your comments will be noted and become part of a master's thesis. They may even be instrumental in producing change in instructional procedures in other groups as well as your own. (improvised responses)

   a. Individual pacing is an innovation that would prove helpful in instruction in anatomy.
   A = 5 B = 5 C = 4 Total = 14

   b. For normal lecture purposes groups should be smaller than 120.
   A = 3 C = 3 D = 3 E = 4 Total = 15

   c. Group C (slide-tape individually paced) is an effective method of instruction.
   C = 5

   d. Method D is effective (slide-booklet individually paced) is an effective method of instruction.
   D = 8

   e. More audiovisual techniques should be used in instruction.
   E = 4

   f. A question period should follow a lecture period.
   E = 3

APPENDIX D

TEST INSTRUMENT

Answer the following questions using test slides. Fill in the blanks by naming the parts pointed to on the diagram. Where necessary explanatory phrases are included.

1. A. ________________ tip of visible portion of outer ear.

   B. ________________ entire visible portion of outer ear.

   C. ________________ lower tip of visible portion of outer ear.

   D. ________________ Secretion in channel of outer ear.

   E. ________________

2. A. ________________ term used with the bones of the middle ear when they are discussed as a unit.

   B. ________________

   C. ________________

   D. ________________

3. A. ________________

   B. ________________ the coiled or sea-shell-like portion of the inner ear.

   C. ________________

4. The coloured portion of this picture is the membranous labyrinth. Outside this labyrinth is a fluid called
   A. ________________. Inside is a fluid called

   B. ________________.

5. A. ________________ is made up of

   B. ________________

   C. ________________

   D. ________________

6. ____________________

Instructions for questions which follow: The following questions consist of multiple choice and short answer questions. On the multiple choice questions one or more of the choices may be correct.

1. Sound waves are
   a. similar to light waves in that they travel faster in a vacuum than in air.
   b. electrical impulses conducted by the air.
   c. impulses originated in the Organ of Corti to be relayed to the brain for interpretation.
   d. are a number of molecules moving out together from a common source.

2. If a number of molecules were to strike a sensitive membrane the membrane would move because:
   a. molecules have weight.
   b. moving molecules exert a force.
   c. molecules have an electrical charge.
   d. membranes are attracted to molecules.

3. Which of the following performs much the same transformation of energy as that performed in the ear?
   a. an electric egg beater takes electrical energy and changes it to mechanical energy.
   b. a water fall provides mechanical energy through moving molecules of water which operate an apparatus that produces an electrical charge.
   c. a drum stick hits a drum head which vibrates and sends out waves of moving air molecules.
   d. the mechanical energy of a hammer moving through the air is changed to heat energy when it strikes a solid plate of steel.

4. To apply liquid medication to the outer ear canal of an adult one must grasp
   a. the top of the visible segment and pull up and back.
   b. the middle of the visible segment and pull back.
   c. the bottom of the visible segment and pull down and back.
   d. One need not manipulate the visible segment but simply apply medication with a sterilized dropper.

5. Which of the following statements relates to the function of the middle ear bones?
   a. Force applied at one point is transferred to another point.
   b. Force applied at the initial point is increased at the terminal point.
   c. The distance of initial movement is increased at the terminal point.
   d. The distance of initial movement is decreased at the termina point.

6. Energy arrives at the middle ear as
   a. electrical energy.
   b. mechanical energy.
   c. potential energy.
   d. hydraulic energy.

7. Equilibrium is
   a. a sense of balance.
   b. a sense of internal sensation.
   c. a sense which provides information regarding the position and motion of the head.
   d. a mechanism responsible for hearing sounds not audible to the rest of the hearing apparatus.

8. Tiny bits of calcium carbonate in the mechanism of equilibrium in the inner ear move as a result of gravitational pull. They are called
   a. otoliths
   b. neuroliths
   c. macula
   d. crista

9. In a short phrase or sentence describe
   a. One useful function of the secretion produced by the outer ear canal. ______________________________

      ____

   b. One possible danger of this secretion. ____________

      ____

10. The object closing the inner portion of the tympanic canal is called the ____________ or ________________.

11. In the middle ear the ______________________________ offer a site for infection to settle and spread.

12. If you used the origination of electrical signals in the mechanism of hearing and equilibrium as a pattern and you were told to find cells responsible for creation of electrical signals in some other organism what kind of cell would you look for? _______________

APPENDIX E

TEST SCORES

In the data which follows student numbers begin with the digits 1, 2, 3, 4, and 5. This is meant to differentiate between the groups; audio-verbal, media-paced; printed-verbal, media-paced; audio-verbal, self-paced; printed-verbal, self-paced, and the group receiving normal instruction.

Student number	Pre-test	Post-test	Retention test
101	12	29	25
102	07	28	15
103	11	33	24
104	11	32	18
105	14	33	23
106	11	34	17
107	11	29	16
108	08	24	17
109	09	29	27
110	08	30	29
111	10	29	18
112	15	35	24
113	11	34	30
114	12	32	24
115	14	32	27
116	11	25	12
117	11	34	30
118	12	26	12
119	10	33	20
201	12	32	26
202	15	35	31
203	19	33	32
204	09	35	27
205	12	32	30
206	08	25	14
207	12	35	32
208	18	31	20
209	11	33	31
210	10	31	15
211	07	27	13
212	11	34	28
213	15	35	32
214	09	32	19
215	09	25	20

216	13	33	22
217	14	33	32
218	10	27	19
219	18	27	18
301	11	32	28
302	11	34	22
303	13	33	30
304	11	31	28
305	11	28	
306	14	33	31
307	12	25	25
308	08	28	18
309	08	20	18
310	10	30	19
311	08	31	25
312	12	32	25
313	09	32	25
314	05	23	14
315	10	28	22
316	16	33	24
317	10	28	22
318	10	28	22
319	09	26	19
401	14	32	27
402	11	33	26
403	09	19	21
404	09	36	27
405	09	34	27
406	07	30	16
407	17	36	25
408	13	31	16
409	11	26	24
410	07	29	11
411	09	28	19
412	11	33	31
413	10	30	21
414	11	34	26
415	12	30	30
416	12	29	25
417	10	22	14

501	09	27	19
502	11	31	28
503	13	29	20
504	12	22	24
505	10	28	26
506	13	23	18
507	12	24	17
508	11	26	18
509	10	22	23
510	11	24	20
511	14	21	19
512	13	22	16
513	10	20	08
514	08	20	16
515	13	24	23
516	07	21	18
517	12	28	15
518	17	27	28
519	07	18	16
520	06	22	21
521	09	21	11
522	10	21	23
523	10	24	21
524	10	24	25