Behavioral Objective Use and Student Performance

Abstract

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The experiment was designed to determine if students provided with behavioral objectives as orienting stimuli would score higher on achievement and attitude measures. Students were divided among three treatment conditions and three ability catagories. The results indicated that students provided with objectives tended to score higher (approx. 5%) on performance measures, but only significantly in three of the seven lab exercises used. Student attitudes towards the instruction were significantly more positive in the treatment conditions although they were more critical of their lab instructors than the control group. Considering development costs, the results of this and similar experiments, it was concluded that directing student behavior with behavioral objectives is not a worthwhile practical strategy until future research can indicate in what conditions they will prove effective.

THE EFFECT OF USING BEHAVIORAL OBJECTIVES IN AN UNDERGRADUATE BIOLOGY LABORATORY ON STUDENT ACHIEVEMENT AND SATISFACTION

by

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Chapter I

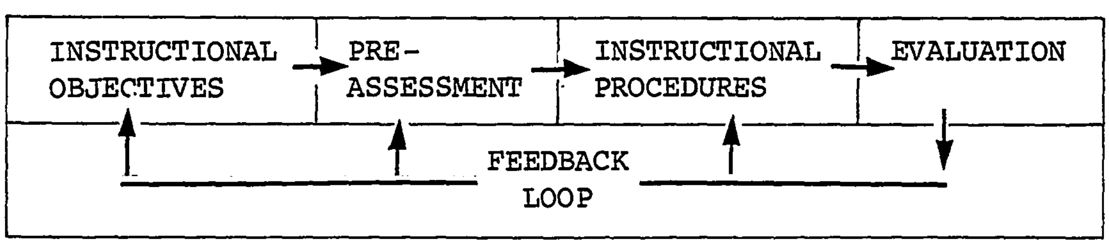
Overview: Behavioral Objectives and the Instructional Model

In 1930 Ralph Tyler came to the conclusion that in order to construct a test to measure the effectiveness of instruction, one has to first identify what is being taught (Anderson et al, 1969). Instructors all wish to have some meaningful effect on their students. Naturally, different students bring to and take from courses a variety of knowledge, values, and skills, but good instruction demands that students are affected in some predictable way, otherwise there would be little need for instructors or courses. As Pascal (1969) states: "Whether we are concerned with developing a single lecture, a course, a curriculum, or an entire university it is necessary for us to decide where we are going before we decide how to get there." From this concern, the idea of "empirically validated instruction" has been put forward as a model towards which instructors can work. The foundation of this approach is the specification of "behavioral objectives" which are the focus of this study.

Behavioral objectives serve two main functions. First, they are used by instructors to design and evaluate their instruction. Second, they are used to communicate the goals of instructional units to (1) students planning to complete the unit; (2) instructors who teach preceding and following units; and (3) persons responsible for planning and evaluating curricula.

The use of behavioral objectives can be illustrated by presenting a breakdown of the major steps in planning and carrying out instruction. In the following paragraphs a "General Model of Instruction" which is applicable to all levels and subject matters in education is presented. Many individuals have contributed to the constitution of this model; perhaps the most important are Gagne (1965a; 1965b; 1965c), Glaser (1965), and Popham (1965).

The major philosophical premise underlying the model is that the goal of instruction is to maximize the efficiency with which all students achieve specified objectives. The purpose of the model is to guide teachers in the major steps of instruction and to provide an overall structure with which to view the instructional process. The model is diagrammed below as outlined by Kibler et al (1970).



Instructional Objectives

The first stage of the process is the selection of appropriate objectives. This selection is based on a number of factors: (1) what the students are able to do before beginning the unit; (2) what the students should be able to do after instruction; and (3) the available instructional resources. Classification of objectives is the step which deals with the problems of making sure the objectives selected are of the type actually desired. Bloom (1956), Krathwohl (1964) and others have developed taxonomies which enable the instructor to classify objectives lying in the cognitive domain into such categories as knowledge, comprehension, application, etc. This provides feedback to the instructor on the complexity and variety of types of objectives. Gagné (1965c) and Guilford (1967) also have produced systems for classifying human performance that are useful for this purpose.

Once a set of broad objectives has been selected, the instructor should perform a behavioral analysis in which he determines what the student will be expected to do to demonstrate the achievement of each objective. One way of achieving this is to examine (1) the stimuli to which the student responds; (2) the responses made; and (3) the criteria which the responses must meet to be considered successful. No matter how the behavioral analysis is conducted, one should define a list of instructional objectives which clearly and completely prescribe the behaviors students are to demonstrate as a result of completing instruction. Behavioral objectives should contain the following three elements as recommended by Mager (1962).

1. A description of the type of observable behavior which the student will be asked to employ in demonstrating mastery of the objective.
2. A description of the important conditions under which the student will be expected to demonstrate achievement of objectives.
3. The criteria which will be used to evaluate the success of the student's performance.

Obviously, not all types of educational goals can be as clearly specified as suggested above; in fact, both critics and proponents of behavioral objectives would agree that the more significant an objective is, the more difficult it is to specify and measure. Such objectives are common in the areas of problem-solving, creativity, attitudes and values and should not be eliminated merely because they are difficult to measure; they should be included and the instructor can work toward their adequate specification and measurement.

Pre-assessment

The pre-assessment stage is to help decide (1) whether any students may omit any of the objectives in the unit; (2) whether any students should be required to master prerequisite skills before beginning the unit; and (3) what specific instructional activities should be provided for specific students.

Instructional Procedures

On the basis of decisions made in the first two stages, instructional procedures are designed by (1) selection of available instructional materials; (2) preparing new instructional materials when necessary; and (3) developing a sequential plan which appears to be most efficient for achieving the stated objectives. Ideally, these decisions are based on research evidence.

Evaluation

When students complete an instructional unit, they are evaluated to determine whether the instruction was successful in achieving the units' objectives. If the objectives have been specified clearly, test preparation to evaluate instruction is relatively easy. In most cases, it is desirable and feasible for all students to master all objectives. If all students do not perform acceptably on all objectives, an explanation must be sought from among at least these three reasons:

1. Students did not have the necessary entering behaviors (prerequisite knowledge) to succeed with the objectives.
2. The students were not motivated properly to master the material (affective objectives).

3. The instruction was not designed properly (e.g. insufficient time was provided for the students to master the objectives).

As a result of the evaluation procedures, changes should be made in other parts of the model (feedback loop) in order to approach more closely a goal of 100% mastery. Results can now be used to give feedback on how well they achieved the objectives for any unit.

The model is simply a logical, rational framework which seems to describe the best way to approach the goal of empirically validated instruction. Whether or not this approach is viable depends to great extent on the ability of teachers to specify behavioral objectives in the practical everyday world of teaching, and second on the effects on student learning of specifying objectives. The next chapter reviews the research and the resulting issues concerned with the use of these objectives.

Chapter 2

Review of Related Literature and Research

The great majority of educational literature dealing with objectives and instruction is intuitively based rather than empirical. The literature contains pleas for stating the objectives of instruction (Glaser, 1964; Krathwohl, 1965; Popham, 1969; Tyler, 1964), rationales for using objectives (Gagné, 1965b; Lindvall, 1964; Popham, 1969; Goodland and Richter, 1966; Beauchamp, 1961; Tyler, 1936), and instructions for writing objectives (Eisner, 1967; Mager, 1962; Payne, 1968; Yelon and Scott, 1970; Maxwell and Tovatt, 1970). This study is concerned with one specific rationale for the use of objectives. The sources cited provide adequate discussions of the other concerns.

Proponants for the stating of objectives usually claim the following three general advantages:

1. Stating explicit objectives and development of matching methods of evaluation will ensure that the evaluation of student progress will be valid, (i.e. the fit between course content and evaluation procedures) instruction will be precise, and inefficient instruction can be identified and corrected.

2. Teachers will become more effective instructors if they have identified their objectives precisely, i.e. teachers energies will be directed towards fostering specific learner behaviors as defined by objectives.
3. The student, by knowing what is expected of him, will be a more effective learner, i.e. he will manage his time better and direct his energy according to known critical outcomes.

However, there are those (Eisner, 1967a; Ebel, 1967; Kliebard, 1968; Jackson and Belford, 1965) who question the value of objectives and feel they might actually be a hindrance to the design of instruction. Atkin (1968) and Popham (1968) discuss at great length these controversies. The most often cited negative effects related to the specification of objectives are listed below:

1. by focusing attention on objectives which are rather easy to specify behaviorally less attention may be given to long term, general goals.
2. to use objectives, the instructor must anticipate all possible outcomes of instruction which in fact is impossible. It is likely that by focusing on behavioral objectives only, other desirable outcomes may go unnoticed.

3. some subject matter, especially those having to do with higher order objectives, (in Bloom's sense) do not lend themselves well to this form of behavioral specification.

After an interchange of views in the literature, Eisner (1967b) responded to his critics by pointing out that the contribution of educational objectives to curriculum construction, teaching, and learning is an empirical problem, while most articles that have been written are merely logical arguments. He further claimed that what little research had been done is at least inconclusive. Let us examine what has been done.

Results of studies testing the validity of the first advantage claimed for the use of behavioral objectives are difficult to interpret in any conclusive way. Many different kinds of instructional systems can be designed around the specification of behavioral objectives and not enough research has been done to provide a general picture. Objectives have been successful in conjunction with an individually programmed instruction system for mathematics learning developed by Glaser and associates at Oakleaf Elementary School in Pittsburg (Lindvall and Bolvin, 1966). Gagne (1965b) used behavioral objectives to develop a successful instructional system for the training of apprentice Air Force mechanics. Programed materials such as textbooks are also heavily dependent on the specification of behavioral objectives (NSSE, 1967). In general, the instructional systems approach has been proved successful when the student criterion behaviors are easily identified as, for example, in the case of elementary mathematical or mechanical skills. The use of behavioral objectives in the design of instruction associated with more complex subject matters has yet to prove beneficial.

With respect to the increased teacher effectiveness due to the specification of objectives, the research has only just begun and results are not consistent. For example, McNeil (1967) collected data which indicated that teachers who were told to focus specifically on student behavior changes as evidence of student learning achieved greater success in teaching, as evidenced by pupil achievement when compared to a group not so instructed. Baker (1969) provided behavioral and nonbehavioral objectives for different groups of teachers and found no significant difference on tests assessing the attainment of the objectives given to the students. Jenkins and Deno (1970) also found no significant performance difference between groups of students who were taught by teachers provided and not provided with objectives. Perhaps McNeil's teachers were more effective because they were required to identify the criterion behaviors themselves, rather than simply being given already defined objectives as was the case with the other two studies. Obviously, more research needs to be done in this area before the question is settled.

The advantages claimed for the specification of behavioral objectives with respect to general instructional design and teacher effectiveness are not the direct concern of this study; it is the last listed advantage (stating that a student provided with behavioral objectives will be a more effective learner by directing his energy according to known critical outcomes) with which this investigation is concerned.

In discussing the condition of learning, Gagne (1964) states that a requirement that may transcend other conditions of learning is that the learner be informed about the nature of the performance expected when learning is completed. Presumably this procedure establishes a continuing set which facilitates learning, perhaps by making possible reinforcement at several points in a sequence of activities (Gagne, 1964). It appears probable that a sequence of instruction which is initiated by communicating to the learner the objectives of instruction is more effective than one that does not begin that way. Mager went a step further and suggested that instructors should give a copy of a course's behavioral objectives to students to help direct their learning (Mager, 1962, p.4). The same advice has been given by several other authors (Bugelski, 1964, p.255; Popham and Baker, 1970, p.78; Klausmeier and Ripple, 1971, p.330).

A study by Mager and McCann (1961) is often cited as supporting the strategy of providing students with behavioral objectives. This study showed that when six engineers were given specific behavioral objectives, references, texts, and an instructor to use when and however they wished, they learned the required performance by proceeding at their own rates with a 65% time saving compared to the usual training time. According to supervisors, these engineers were performing satisfactorily six months later and had made more decisions on their own than former trainees. Their design, however, includes the use of an instructor and therefore it is impossible to decide whether the time saving was due to the provision of objectives, the availability of the instructor, or both. This same objection can also be made of two other studies.

Objectives were used to guide independent study in biology, chemistry, and physics at Marple Newton High School. In this study described by DeRose (1968), students were provided with objectives and a mentor to give direction and advice as needed. The objectives were used by the independent study student in determining what he is expected to be able to do when he has completed his study and also as a means of determining when the study has been completed. The results of this study thus far indicate that high school students can direct their own learning when provided with objectives and a mentor. The students in the independent study program performed as well as students in conventional classes on examinations covering topics studied by both groups.

Allen and McDonald (1963) conducted an experiment at Stanford University in which the subjects were required to learn the pieces, rules, and strategies of a new game. The subjects were divided into two groups. One group utilized a linear program as a means of instruction, while the other group was provided with a set of objectives describing what should be learned. In addition, the members of the group provided with objectives also had access to an instructor. The role of the instructor was to give assistance only when asked. The members of the group controlling their own instruction were not systematic in their approach to learning, but they performed almost as well as the group with the linear program. The group controlling their own instruction also required only half the time of the group with the linear program to complete the requirements. Unfortunately, their design also did not provide a convincing test of the strategy of providing students with objectives because of the instructor availability.

Tiemann (1965) used prior knowledge of general and specific objectives in investigating student achievement and attitude in relationship to programmed instruction. Objectives in eight video-taped lectures were defined in terms of observable student performance and subsequently validated. Two groups of students viewed programmed revisions and two groups viewed conventional revisions based on intuitive procedures. In each case, one group was provided with general objectives which were designated as implicit in the lectures while the other group received the specific objectives. A pre and posttest were administered to each group along with a standardized questionnaire which assessed six attitude factors. The provision of specific objectives was associated with a greater preference for more objectives, greater use of objectives, and a favorable attitude. Immediate posttesting indicated that high scores were associated with programmed lectures but not with specific objectives. Later testing as part of the final examination showed high scores to be associated with specific objectives but not with programmed lectures. Tiemann suggested that the association between objectives and criterion-referenced tests was not perceived until the mid-term posttest which structured the contingencies for the use of objectives.

Yelon and Schmidt (1971) studied the effect of objectives and instructions on the learning of a complex cognitive task. Their research, besides using objectives as a mode of definition of a desired outcome, used task-related instructions as another type of orienting stimuli. Briefly, the results indicate that the effect on learning of objectives was either neutral or negative, while the effect of instructions was neutral or positive. In this case, the task was to learn to play a novel game called "Think-a-Dot", which was chosen because the type of learning required was complex.

Merrill (1971) recently completed research on the effects of the availability of objectives and rules on the learning process. It was concluded that objectives have orienting and organizing effects which dispose students to attend to and organize relevant information and thus facilitate performance on criterion-test items constructed in accordance with objectives. These effects, however, were not as pronounced when the learning task contained other orienting stimuli such as rules. For his subject matter, he constructed an imaginary science.

Cronbach (1957) states:

> In general, unless one treatment is clearly best for everyone, treatments should be differentiated in such a way as to maximize their interaction with aptitude variables. Conversely persons should be allocated on the basis of those aptitudes which have the greatest interaction with the treatment variables.

Cronbach is making the case that a person will learn from one method better than another, but that this best method will likely differ from person to person depending on such variables as ability or personality. This idea may have implications for the use of behavioral objectives.

At an AERA symposium (Walbesser, 1970) some discussants professed the belief that behavioral objectives are more useful for the "average-ability" student than the high or low ability group. It was felt that objectives would be restricting for high ability and perhaps confusing for the lower ability group. A little work has been done in this area. Doty (1968), for example, investigated the effectiveness of providing male seventh-grade industrial arts students with the objectives and practice on an actual referent. The instructional unit involved the reading and the calculating of the value and tolerance of axial resistors. Four treatment groups were used. One group received specific objectives before instruction and practice on the actual referent. The second group received specific objectives and practice on the verbal symbolic referent. The third group received no objectives and practice on the verbal symbolic referent. The fourth group received no objective and practice on the actual referent.

The data collected (on immediate student learning) in this study indicated a tendency for students in the upper ability level to benefit in their immediate learning as a result of receiving prior knowledge of objectives and practice on the actual referent. The students in the average ability level showed no difference in immediate learning as a result of the treatments. The students in the low ability level had equal or higher immediate learning than the average ability students when they received prior knowledge of objectives and practice on the actual referent or the verbal symbolic referent. The students in all ability levels who practiced on the actual referent and did not receive prior knowledge of objectives had low immediate learning when compared to the students who received other treatments.

In a study by Bryan and Locke (1967) objectives were used in investigating motivation. Ten male and ten female volunteer college students were used as subjects. The tasks given to the subjects were problems in simple addition. After the first session the subjects were divided into two groups based on the dichotomy of high and low motivation. At succeeding sessions, the subjects with high motivation were told to "do their best" in performing the addition problems, while the subjects with low motivation were given specific goals to reach in terms of the number of problems completed and the accuracy of answers for problems completed. The performance and attitude of the subjects with high motivation were lowered while the attitude and performance improved for the subjects with low motivation.

Colin (1970) concluded in a study of grade seven science students that those with prior knowledge of the objectives of instruction performed slightly higher than those without prior knowledge of objectives, but the difference was not significant. The students were also divided into high, medium, and low ability groupings using the California Test of Mental Maturity; the students' ability level was found not to be related to use of objectives and resultant student achievement.

Several points become evident when reviewing the literature concerning objectives and the educational process. There is some support for the use of objectives in instructional design and evaluation and some research on the advantages to the learner of prior knowledge of objectives. Evidence suggests that students can utilize objectives to good advantage to direct their own independent study. The limitations of the research thus far, however, leaves some question about the relationship between knowledge of the nature of the desired outcome and performance on that outcome. In some cases students benefit when provided with objectives, in others they do not. The content and instructional approach in the studies are so diverse that none of the studies replicate each other. Many studies were not designed so that the effects associated with student use of behavioral objectives could be separated from other techniques used, as for example in the studies combining use of specific objectives with availability of an instructor. Some studies are of a laboratory or semi-contrived nature which are far removed from the type of instruction or content which is common in our schools. Not much attention has been focused on prior knowledge of objectives of an on-going, pre-determined instructional program. And lastly, and perhaps most important; there has simply not been enough studies done in order to construct any kind of meaningful picture. Thus far, research dealing with the effect of learning on conditions regarding knowledge of instructional outcomes is inconclusive. In view of the large amount of positive recommendations in curriculum literature to provide students with objectives in specific behavioral terms, it is evident that much more research is needed in this area.

I set out, then, to investigate the following questions*:

1. Can behavioral objectives be generated and used successfully by instructors in an existing course at McGill University?
2. What will be the effect of providing students with specific behavioral objectives; will they

*Detailed hypotheses are listed in the next chapter.

score higher on achievement measures than those not provided with objectives; will students be more satisfied with a learning environment which includes behavioral objectives?

3. Does student ability level or motivation determine to any extent how useful behavioral objectives are?

Chapter 3

Procedure and Design

To provide students with behavioral objectives in a real classroom setting requires a great deal of initial preparation, as well as considerable cooperation from the instructors involved. The objectives must be written (a considerable task), then typed printed and distributed to the students at appropriate times. Posttests must be constructed, administered, the scores calculated and returned to the students promptly. All of this involves several people with differing attitudes, abilities and conceptions of their role in the situation.

To adequately test the strategy of providing students with orienting stimuli in the form of behavioral objectives, the study was carried out in a long-established undergraduate course at McGill University, with the preparation and administration of the materials done by people already involved as regular instructors in the course. Obviously, the effectiveness of any instructional strategy must be proved when used in a practical real-life learning environment by regular instructors. Information collected from a strategy tried in a controlled laboratory experiment using unusual subject matter or in a small course closely supervised by "experts" does provide valuable knowledge, but ultimately its effectiveness must be tested in a practical situation with its limited resources and potential control problems. For this reason, the author chose to sacrifice strict control of the study in order to provide a practical test of the effect of specific objectives as orienting stimuli.

Subjects

The study was carried out in the laboratory periods of Biology E10 (introductory) at McGill University over a seven-week period in early 1970. A total of 236 students were involved in the treatment conditions. Biographical information collected from the students indicates that over 90% were first-year general program students. Male and femals proportions were approximately equal.

Preparation of Materials

The objectives were prepared from the existing laboratory manual which was written by various members of the Biology Department. Two graduate students in zoology wrote specific behavioral objectives for seven separate lab exercises as presented in the manual. Each objective was scrutinized by the author to ensure that it matched the content of the lab manual, and that it was written in specific behavioral terms as outlined by Mager (1962) and Yelon and Scott (1970). This was not difficult, as most of the content consisted of simple factual knowledge (names and functions, definitions, phylum level, etc.). If the Biology Department had any higher-order objectives for the lab exercises, they were not visible in the lab manual.

For each lab exercise a pretest and posttest were also prepared, and care taken to ensure that each test was a comprehensive sample of the content areas of each exercise. It was not possible, due to time constraints, to administer a criterion item for every behavior specified. The pretest was designed to measure the achievement of a small number of objectives which students in one treatment group were expected to accomplish before entering the lab. All student responses to these tests were entered on IBM cards and scores computer-tabulated to provide fast feedback to the students.

A questionnaire designed to measure student attitudes about the lab environment was constructed and administered before and after the experiment.

Examples of all these materials are in the appendix.

<u>Design</u>

Each of the three treatment groups was composed of the following elements:

Treatment no. 1	Objectives, Pretest-Remedial,	Posttest
Treatment no. 2	Objectives	Posttest
Treatment no. 3		Posttest
Treatment no. 4	Control	

The first group received objectives for each lab exercise (a total of seven exercises) one week in advance of the lab period. A small percentage of each week's list of objectives was marked with an asterisk (*) to indicate the objectives each student must accomplish before entering the lab. A pretest was administered to each student to sample the entering behavior specified. If the student reached the criterion level (85%), he was allowed to begin the lab, otherwise he attended a half-hour remedial session designed to bring him up to criterion level. In this way, all students in treatment Group no. 1 began the lab exercise with at least some knowledge of the organism being studied. The final element was the posttest which each student wrote at the conclusion of the lab period. The results of this test were posted within three or four days, along with information on how to correct errors. Pretest and posttest scores were not used for grading purposes within the course; students were told that scores would be used only for purposes of providing them with feedback on their progress.

The remaining two treatment groups received the same experimental elements with the exclusion of the pretest-remedial situation in Group no. 2, and both the objectives and pretest-remedial phase in Group no. 3. With this design, it was possible to measure the effect of each of the three treatment elements on the dependent variables under consideration. In some of the analyses to be discussed later in this chapter, a Treatment Group no. 4 became part of the design; this group was a control consisting of regular students who received no treatment elements.

The experiment was done in the second term (Jan-March) of the laboratory course. The labs were held at five different sessions of a three-hour duration each, on four separate days of the week. The students were divided at random into eight sections each session (total of 40 sections). Each section, consisting of approximately 12-15 students, was led by a different lab instructor. Each of the three treatment groups, then, consisted of six sections.

The sections were not assigned exactly at random to the treatments, as a few lab instructors were reluctant when approached to take on the added duties of administering tests or teaching the remedial sessions. The lab instructors also varied on the number of years of teaching experience, and on attitude and personality variables related to teaching. Even though the students were assigned to the sections at random, there was doubt that the sample populations in the three treatment groups were matched properly in terms of instructor effectiveness and resulting outcomes, therefore the section mean scores on a lab test given at the end of the first term was used as a covariate in the analysis of the data to statistically equalize the treatment samples.

Procedure

Traditionally, all students enter the lab, receive a ten-minute television introduction, and then do the exercises required for the day, using the lab manual as a guide. Students in Treatment Group no. 1 took the pretest after the television introduction. These tests were scored immediately by the lab instructor, and those reaching the criterion level (85%) were allowed to begin the exercise. Those who failed the pretest joined the lab instructor at his desk for a 15-30 minute review of the missed objectives, until he was satisfied that each student had reached criterion level. All students with objectives were encouraged to use them in close conjunction with the instructions in the lab manual. In fact, this encouragement was unnecessary as these students were typically observed to make extensive use of the objectives throughout the period. The posttest was administered to each student upon completion of the lab exercise.

Ability Level

As mentioned earlier, there are some hypotheses generated in the literature (see for example Walbesser, 1970) relating to an interaction between ability level of the students and the provision of orienting stimuli, such as behavioral objectives. To provide a test for these hypotheses, the treatment effects of the experiment were studied within a low - medium - high ability framework. Each student in the experiment was assigned one of these ability levels, according to his overall year's average for 1969-70. The students were simply ranked and divided into three equal groupings (33% each). This ability ranking, then, is really a general measure of a student's performance, which would include his ability as well as his motivation related to academic achievement.

Dependent Variable Measures

(a) Posttest Scores

The posttest scores should provide the best measure of the effect of the behavioral objectives on student performance, as each test represents a good sample of the behavior specified in the distributed objectives. Each student in the objective groups used seven sets of objectives and took the posttest each week. This should provide a more reliable test of the general hypothesis than the final lab exam, which was prepared in reference to the lab manual and past years' exams, and which may not have been a good comprehensive sample of the material in the seven weeks of exercises.

(b) Final Lab Exam

The final lab exam was administered one week following the end of the experiment. It was constructed by the regular supervisors of the lab course. As mentioned above, one would expect any treatment effects appearing to be of a lesser magnitude in the case of the final exam than with the posttest scores, although some treatment effects should appear on this measure as it was designed to grade students on their efforts during the experimental period. There was no actual reliability statistics available for these two performance measures, but these measures were typical of university tests used for introductory biology and their reliability was assumed to be high. The validity of the posttest measures was good considering that each test represented a comprehensive sample of the defined objectives. The final lab exam measure may be less valid but it was used as a criterion for passing the lab course and at least has "validity in the system".

(c) Student Attitudes

Student attitudes about any particular learning environment would seem to be related to their performance. A student with negative attitudes toward an instructor or course is more likely to perform at a lower level than otherwise. Some students enter an instructional situation with preconceived attitudes toward it, others develop or change attitudes after exposure to the learning environment.

One question of major interest was whether the treatments were having an effect on such attitudes. To measure student perceptions of the laboratory, a questionnaire was administered to all students before and after the experiment. In an attempt to avoid bias, replies were anonymous, with the exception that all students were asked to identify the lab section to which they belonged. It was therefore possible to group the item means under the four treatment groups. It was not possible, however, to include ability levels in the design for this data.

The intercorrelations between items on the questionnaire indicated that groups of questions could be considered together. Three such groupings were identified and considered here. Table 1 on page 30 gives a listing of each item under the three groupings - lab organization, instructor effectiveness, and overall satisfaction.

In summary, the general design consists of two fixed factors - treatment and ability - with three or four levels of treatment and three levels of ability. The three dependent variables were posttest scores, final lab exam scores and student attitude data. Following are the specific hypotheses of this study:

A. Student Performance on Posttest

H1: Students provided with objectives (Treatments no. 1,2) will achieve higher scores on the posttests than those not provided with objectives (Treatment no. 3).

H2: Students provided with a pretest-remedial situation

TABLE 1

Attitude Items

Attitude Items (Rated on 1-5 scale)	
Lab Organization	
1. Objectives clear	objectives unclear
2. Well organized	confused
3. Stimulating	boring
4. Worth attending	useless
5. Content good	content bad
Instructor Effectiveness	
6. He interprets ideas and theories clearly	Bad . . . Good
7. He makes good use of examples and illustrations	Bad . . . Good
8. He has made the material interesting	Bad . . . Good
9. Communicated his enthusiasm to the class	Bad . . . Good
10. Is available for personal help	Bad . . . Good
11. Is well prepared for class	Bad . . . Good
12. His teaching is effective	Bad . . . Good
13. His presentations are stimulating	Bad . . . Good
14. Deals with student questions adequately	Bad . . . Good
Overall Satisfaction	
15. I was very interested in this field of study	am not interested in this field of study.
16. This course is very relevant to my personal goals	this course is very irrelevant to my personal goals.
17. I will be taking more senior courses in this field	I will not be taking more senior courses.
18. This laboratory had a great impact on me	this laboratory had no impact on me.
19. My expectations of the lab were met	my expectations were not met.
20. I would recommend this course to my friends	I would not recommend this course to my friends.
21. Overall, I am extremely satisfied with the labs	overall, I find the labs very unsatisfactory.

(T.no.1) will achieve higher scores on the posttest than those not provided (T. nos. 2,3).

B. Student Performance on Final Lab Exam

H3: Students provided with objectives (T.nos.1,2) will achieve higher scores on the final lab exam than those not so provided (T. nos.3,4).

H4: Students provided with a pretest-remedial situation (T. no.1) will achieve higher scores on the final lab exam than those not so provided (T.nos.2,3,4).

H5: Students provided with weekly posttests (T.nos.1,2,3) will achieve higher scores on the final lab exam than those not so provided (T.no.4).

C. Student Attitudes

H6: Students provided with objectives (T.nos.1,2) will be more satisfied with the lab instruction as measured by an attitude questionnaire than those not so provided (T.nos.3,4).

H7: Students provided with a pretest-remedial situation (T.no.1) will be more satisfied with the lab instruction as measured by an attitude questionnaire than those not so provided (T.nos.2,3,4).

H8: Students provided with weekly posttests (T.nos.1,2,3) will be more satisfied with the lab instruction as measured by an attitude questionnaire than those not so provided (T.no.4).

D. Ability Level

H9: Students in the middle ability range (as defined by previous laboratory performance) in Treatment Groups nos.1 and 2 will be more positively affected by the treatments (higher score differentials on posttest and final lab exam) than the low and high ability groups when compared with the corresponding groups in Treatments nos.3 and 4.

Analysis

(a) Performance Measures

To provide a good indicator of the difference between the cell means an analysis of covariance was used to examine the posttest and final lab scores. The analysis was identical for both of these variables, with the exception of one more treatment level for the final lab scores (Control) and in the case of posttest scores the analysis dealt with a seven-week series of data. A Program entitled "NYBMUL" (Dr. D. Bock, Director of Preparations) and designed for the IBM 7094 computer, was used for the analysis.

(b) Attitude Measures

It was deemed inadvisable by the author to apply a regular one-way analysis of variance to the attitude data as the distribution of item scores was highly variable, and also such measures can really only be classified as ordinal data. Therefore, the Kruskal-Wallis H test (Hays, 1963) was used as it is similar to the analysis of variance, except that the calculations are based on ranks rather than the actual item means.

Chapter 4

Results

The results are presented through the medium of tables and graphs. For each of the three dependent variables, (posttest, lab attitude) three tables illustrate the means, the design used for the analysis, and a summary of the calculated ratios and significant levels.

Posttest Scores

The posttest means and design are summarized in Table 2. A graphic representation of the means is shown in Figure 1. An inspection of the graph indicates that in general the pattern of posttest scores is in the direction predicted by hypotheses nos. 1 and 2 for the first five weeks of the study; for the last two weeks it is not.

A summary of the statistics used for the analysis of covariance carried out on the posttest data is illustrated in Table 3 while Table 4 includes the F-ratios and significance levels obtained. The treatment effect was found to be statistically significant ($p < 05$) except in week no.5. The ability level effect was significant only in weeks 2 and 6. A significant interaction effect appears in weeks 4 and 5.

Overall, then, with respect to the posttest scores achieved the treatments cannot be considered equivalent. The

Table 2
Experimental Design: Posttest Scores

Treatment	Ability Levels	N	Posttest Means						
			W_1	W_2	W_3	W_4	W_5	W_6	W_7
(T_1) Objectives Pretest-Remedial Posttest	Lo (A_L)	24	70.9	81.0	86.2	77.3	64.5	49.0	57.6
	Med (A_M)	23	74.1	87.7	87.4	73.7	69.1	47.8	67.1
	Hi (A_H)	22	77.2	89.5	88.5	83.1	78.3	57.7	72.9
(T_2) Objectives Posttest	Lo (A_L)	22	75.3	69.0	78.0	70.8	67.9	51.9	59.0
	Med (A_M)	26	77.6	75.7	87.8	68.7	77.1	60.8	61.9
	Hi (A_H)	35	77.1	79.7	88.9	75.2	73.8	62.2	63.2
(T_3) Posttest	Lo (A_L)	22	67.1	71.3	78.0	64.3	69.7	47.0	66.6
	Med (A_M)	33	69.2	69.1	81.5	74.3	67.1	55.1	66.9
	Hi (A_H)	29	73.6	82.5	82.2	71.3	69.9	54.6	73.7

Each mean in Table 1 represents the mean score of subjects receiving treatment T_i, having an ability level category of ability A_j (Low, Medium, High) on a posttest administered during Week W_k (W_1-W_7). The design denotes seven measures of each subject's performance.

Figure 1. Posttest Mean Scores

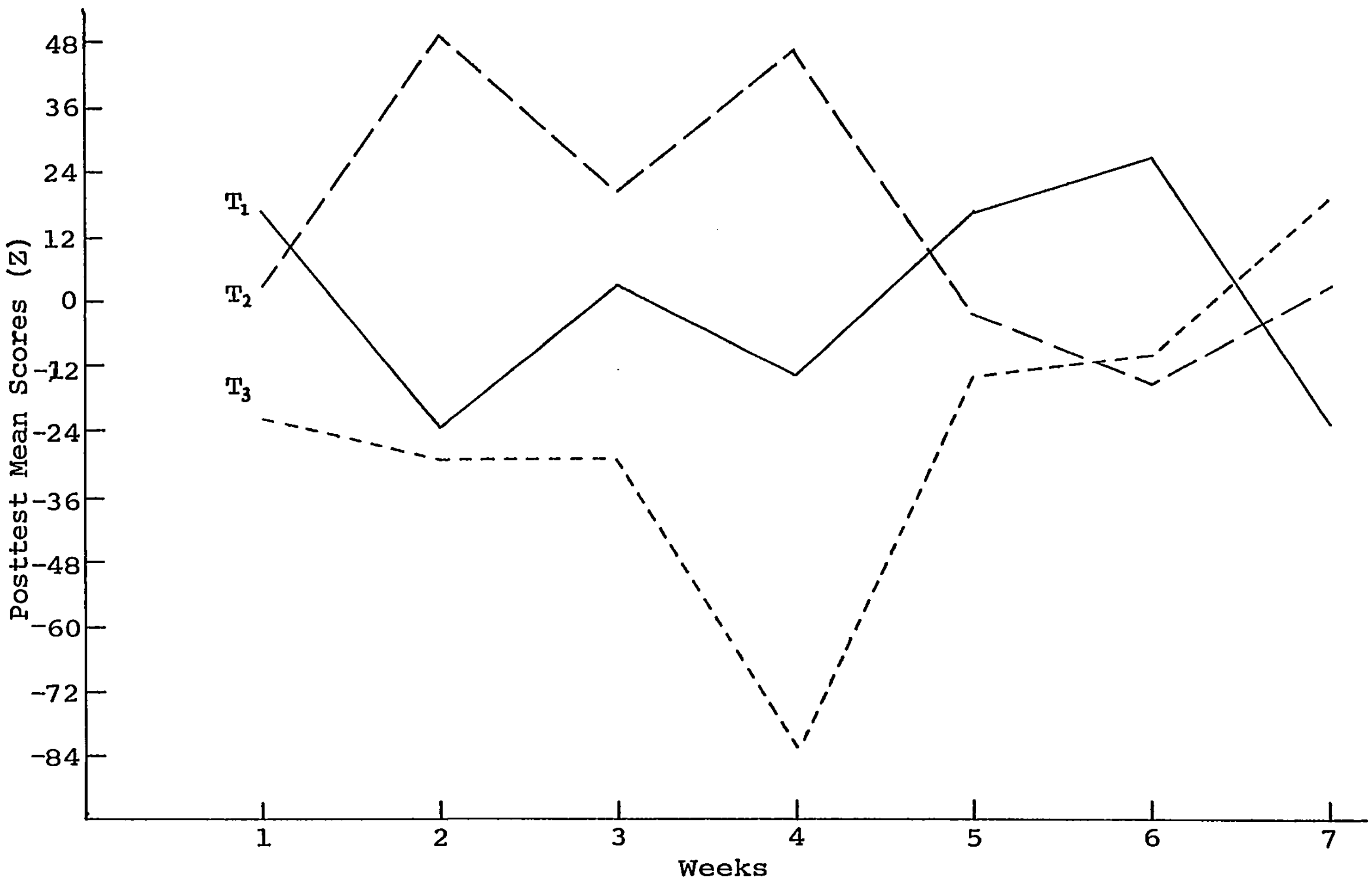


Table 3
Summary of Analysis of Covariance: Posttest Scores

Source of Variation	df	F Ratio
T (Treatments)	R-1	MS/MS_{error}
A (Ability Levels)	C-1	MS/MS_{error}
TxA Interaction	(R-1)(C-1)	MS/MS_{error}
Error (Within)	RC(n-1)	MS/MS_{error}

This analysis for the posttest was applied to all posttest scores in the seven week series simultaneously, yeilding the above F ratios for each week plus overall ratios. There were three treatments, R=3 and three ability levels, C=3. There were RC=9 cells with an average of 26 observations each week (see Table 2 for exact cell N)and a total weekly N=236. Variance estimates were adjusted using the subject's first term laboratory score as the covariate.

Table 4
F Ratios for Analysis of Covariance on Posttest Scores

Source of Variation	df	F Ratio							
		W_1	W_2	W_3	W_4	W_5	W_6	W_7	Overall
T (Treatment)	2	3.6[a]	13.7[b]	4.6[a]	8.9[b]	2.2	4.4[a]	3.5[a]	5.8[b]
A (Ability Levels)	2	0.1	4.0[a]	0.9	2.7	1.8	5.3[b]	1.2	1.5
TxA Interaction	4	0.3	1.3	0.6	3.3[a]	2.7[a]	1.1	0.9	1.4[a]
Error (Within)	226	245.0	235.2	196.1	137.4	180.0	23.9	356.3	

[a] $p < .05$ [b] $p < .005$

level of student ability, which normally would show a high relation to achievement measures such as a posttest of this type, was a significant influence on the scores achieved only in weeks 2 and 6, although in the overall test, was also statistically significant. The interaction effect, as with ability was found to be weak, showing up significant only in two instances and on the overall test. More detailed comparisons among treatment groups are discussed in the planned comparisons section.

Final Lab Scores

The final lab exam means are summarized in Table 5. A graphical representation is shown in Figure 2. These results, then, do not appear to support hypotheses 3 and 4,although there is some support for hypothesis 5, which states that those students provided with a posttest will score higher than those not so provided, at least in the low ability group.

The analysis used was identical with that shown in Table 3, with the addition of the control group (T4). The F-ratios and significance levels are listed in Table 6. Both treatment and ability level were found to bear statistically significant relationships to the final lab scores obtained. There was no indication from the results of any interaction between treatment and level of ability. (Treatment group standard deviations obtained for the two performance measures are

Table 5
Experimental Design: Final Lab Scores

Treatment	Ability Levels	N	Final Lab Means
(T_1) Objectives Pretest-Remedial Posttest	Lo (A_L)	24	46.8
	Med (A_M)	22	47.7
	Hi (A_H)	22	54.7
(T_2) Objectives Posttest	Lo (A_L)	23	42.2
	Med (A_M)	26	49.1
	Hi (A_H)	33	54.3
(T_3) Posttest	Lo (A_L)	22	47.7
	Med (A_M)	35	48.9
	Hi (A_H)	29	55.5
(T_4) Control	Lo (A_L)	88	41.1
	Med (A_M)	103	47.2
	Hi (A_H)	90	54.2

Each mean in Table 3 represents on a final lab exam the mean score of subjects receiving Treatment T_i, having an ability level category of A_j (Low, Medium, High).

Figure 2. Final Lab Exam Mean Scores

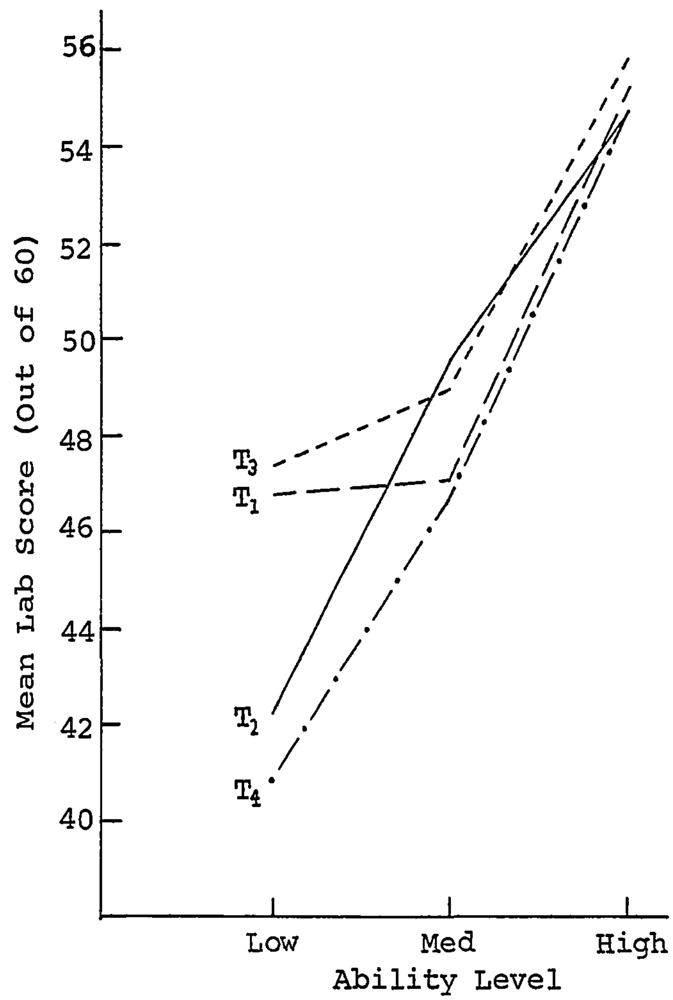


Table 6

Summary of Analysis of Covariance: Final Lab Scores

Source of Variation	df	F Ratio
T (Treatments)	2	19.7[a]
A (Ability Levels)	3	3.1[b]
TxA Interaction	6	0.3
Error (Within)	504	

[a]$p < .05$ [b]$p < .005$

There were four treatments, R=4 and three ability levels, C=3; RC=12 cells with a varying number of observations in each cell(see Table 3)and a total N=517. Variance estimates were adjusted using the subject's first term laboratory score as the covariate.

included in Tables 1 and 2 of the Appendix).

Attitude Data

The attitude item means and design are summarized in Table 7. A Graphical summary is given in Figure 3. In general these data indicate that students in the three treatment groups feel that the lab is better organized and more satisfying than those in the control group (T4). Contrary to the hypotheses, however, students in the treatment groups are more critical of this lab instructor than were those in the control group.

A summary of the "Kruskal-Wallis H Test" used for the analysis appears in Table 8, while the H values themselves are listed in Table 9. Results imply that treatments did influence students' perceptions of the lab environment.

Planned Comparisons

The F and H values determined in the preceding analysis consist of "omnibus tests" made among the sets of means collected for the three dependent variables. These statistics give us an overall picture of the data, but do not provide a specific test of the nine hypotheses outlined in Chapter 3. In order to do this, the posttest and final lab treatment means were tested according to each hypothesis using an F test as described by Winer (1963, p.238). The attitude data were analyzed in a similar fashion, using the Mann-Whitney U Test (Winer, 1962, p.623). An explanation and a summary of these

Table 7
Experimental Design: Attitude Measure

Treatment	N	Attitude Item Means				
		Lab Organization (1)	Instructor Effectiveness (2)		Overall Satisfaction (3)	
(T_1) Objectives Pretest-Remedial Posttest	69	1.7	3.9	4.0	2.4	2.4
		1.9	3.7	3.9	2.7	2.5
		2.6	3.6	3.5	2.6	
		1.8	3.6	4.1	3.2	
		2.1	4.1		2.7	
(T_2) Objectives Posttest	74	2.0	3.8	4.0	2.1	2.2
		2.1	3.7	3.9	2.5	2.3
		2.4	3.6	3.4	2.9	
		1.9	3.5	3.8	2.6	
		1.5	4.2		2.4	
(T_3) Posttest	56	2.4	3.8	3.7	2.2	2.7
		2.1	3.6	3.6	2.5	2.6
		2.7	3.5	3.3	2.5	
		2.0	3.5	3.8	3.0	
		2.3	3.7		2.8	
(T_4) Control	192	2.3	4.1	3.9	2.5	3.1
		3.1	4.6	3.8	2.7	3.0
		2.7	4.9	3.8	3.2	
		2.3	3.8	4.3	2.8	
		2.9	4.0		2.9	

Each mean in Table 6 represents the mean score of subjects receiving treatment T_i; within a grouping of attitude questions G_j (Lab Organization=1, Instructor Effectiveness=2, Overall Satisfaction=3) on a specific item, Q_k (21 items total). See Table 1 for listing of attitude items.

Figure 3. Attitude Grouping Mean Scores

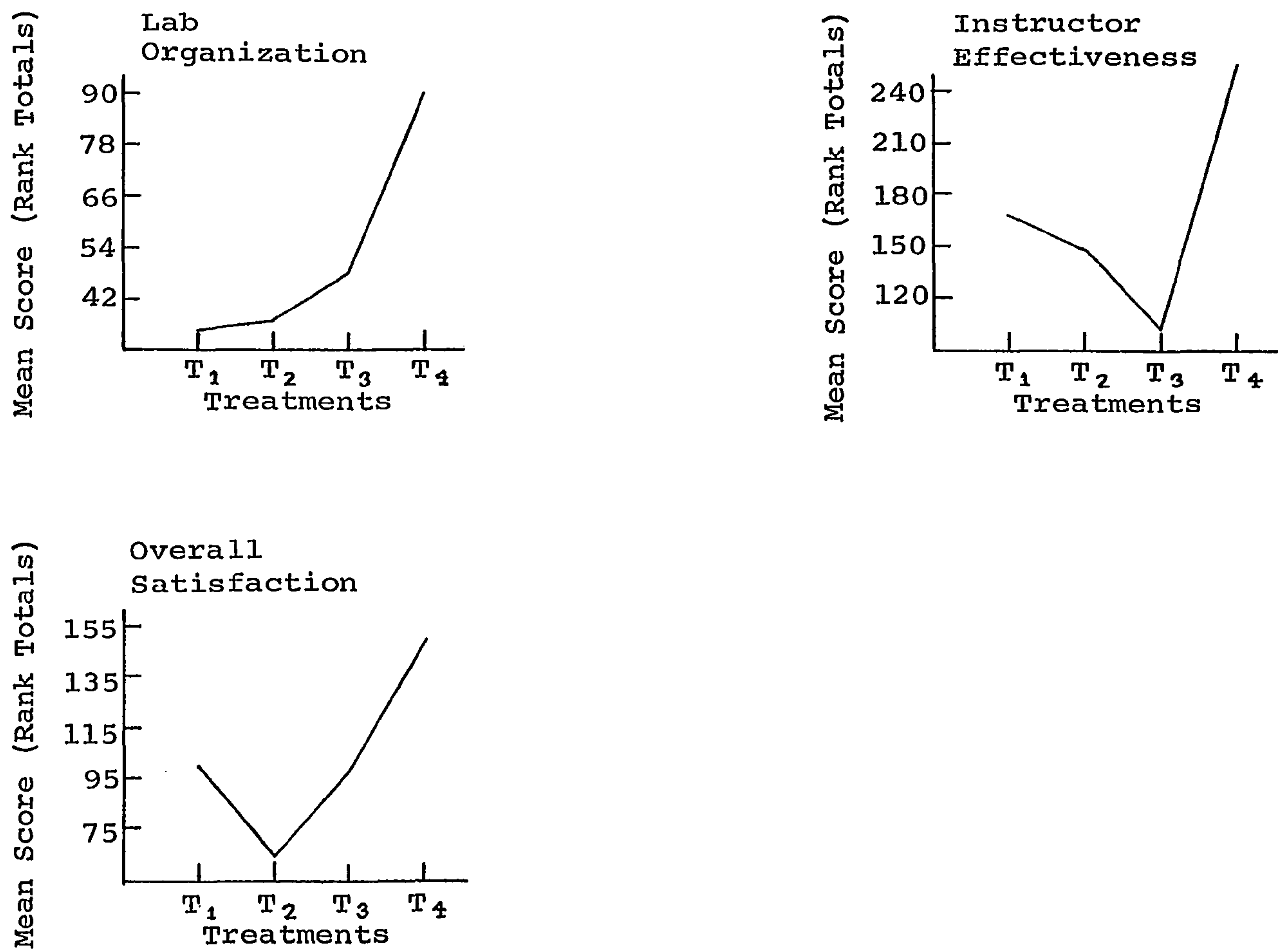


Table 8
Kruskal-Wallis H Test (Analysis of Variance by Ranks:
Attitude Data

H Statistic	H Formulation	df
$\frac{\text{SS Treatment}}{\text{MS Total}}$	$\frac{n}{N(N+1)} - Jn(N+1)$	J-1

There were four treatments, J=4 and three groupings of attitude data to which the H test was separately applied, (Lab Organization, Instructor Effectiveness, Overall Satisfaction). For details on design and attitude items see Tables 1 and 7.

Table 9
Summary of Kruskal-Wallis H Test: Attitude Data

Attitude Item Cluster	H Value	df
Lab Organization	53.2[b]	3
Instructor Effectiveness	56.7[b]	3
Overall Satisfaction	62.4[b]	3

[b] $p < .001$

tests are included in Table 10.

These tests indicate that in general the hypotheses relating to the posttest data (not including interaction effects) were supported by the student performance measures in weeks 2, 3 and 4, but not during the other four weeks. The final lab data supports only hypothesis no. 5 that students provided with weekly posttests achieve higher than those not so provided. As was indicated earlier, the attitude data generally support the hypotheses, except for the data covering instructor effectiveness, where the treatment groups indicated a more critical rather than favourable opinion of their lab instructor, in comparison to the control group.

Hypothesis no. 9 states that students in the middle ability range who are provided with objectives will be more positively affected by the treatments than those in low or high ability groups. Significant interaction effects (see Table 4) were found only in weeks 4 and 5. In order to examine the data for any indication of a consistent interaction effect, the posttest means for weeks 4 and 5 and the average over seven weeks were graphically represented in Figure 4. The covariate (first term lab mark) means were also plotted as a rough indication of the expected distributions in the absence of treatment conditions.

Table 10
Planned Comparison Results and General Hypotheses

Hypotheses	F Ratios: Posttest Data W_1	W_2	W_3	W_4	W_5	W_6	W_7	Over-all	Final Lab Data	Z Statistic: Attitude Data Org	Inst	Satis
Objectives-None $T_1T_2>T_3(T_4)$	3.74	8.68[b]	8.88[b]	8.89[b]	2.49	1.52	4.38[b,c]	2.98	–	-2.65[b]	-0.5	-2.1[a]
Pretest, Remedial-None $T_1>T_2T_3(T_4)$	--	30.6[b]	6.25[a]	20.7[b]	–	–	–	2.42	–	-7.5[b]	-0.3	-0.5
Posttest-None $T_1T_2T_3>T_4$									3.9[a]	-3.4[b]	-0.5	-1.84[a]

Dependent Variable Planned Comparisons

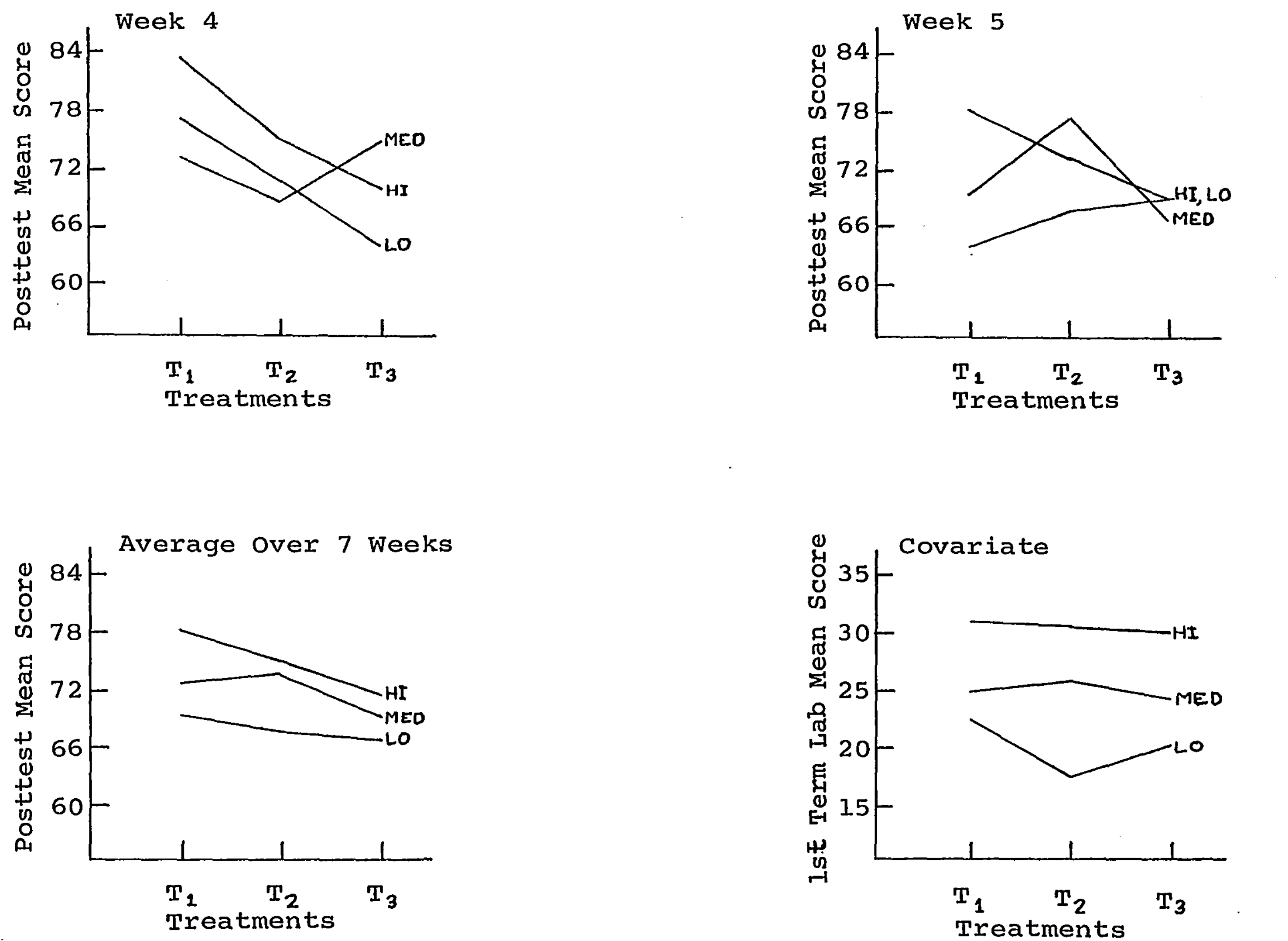
[a]$p<.05$ [b]$p<.005$ [c]Groups significantly different but in opposite direction from hypotheses

This table contains the results of planned comparisons (see text for statistics used) related to the following three hypotheses:

1. $T_1T_2>T_3(T_4)$ - Students provided with objectives(T_1,T_2) will achieve higher performance ratings(posttest scores, lab exam scores) and will be more satisfied with lab instruction (attitude data) than those not so provided(T_3,T_4). T is excluded with posttest data.
2. $T_1>T_2T_3(T_4)$ - Students provided with pretest-remedial situation(T_1) will achieve higher performance ratings and will be more satisfied with lab instruction than those not so provided(T_2,T_3,T_4).
3. $T_1T_2T_3>T_4$- Students provided with weekly posttests(T_1,T_2,T_3) will achieve higher performance ratings and will be more satisfied with lab instruction than those not so provided(T_4).

Blank spots (-) were nowhere near significance.

Figure 4. Comparison Between Posttest Mean Scores and Covariate Mean Scores



Upon close examination of these graphs, and considering that interaction effects appeared in only two of seven weeks of testing, it is apparent that the data do not support the interaction hypothesis. An examination of the high ability groups, however, indicates a tendency for high ability students to score on the posttest in proportion to the number of treatment elements they are exposed to. In other words, the high ability group during these two weeks performed as predicted by the hypothesis, whereas the others did not show any consistent pattern.

Summary of Results

Significant differences found between any group of means indicates only that a difference exists within a certain probability range. The magnitude of such differences is, of course, an extremely important consideration in the interpretation of such data. A summary of the results with the magnitude of significant differences is presented in Table 11.

Table 11
Location and Magnitude[a] of Significant Differences

Hypotheses	Posttest Significance								Final Lab	Student Attitudes		
	W_1	W_2	W_3	W_4	W_5	W_6	W_7	Over-all		Org	Inst	Satis
$T_1 T_2 > T_3 (T_4)$		yes +6.5%	yes +5.6%	yes +6.2%						yes +8%		yes +4.6%
$T_1 > T_2 T_3 (T_4)$		yes +11.5%	yes +4.5%	yes +7.9%						yes +12%		
$T_1 T_2 T_3 > T_4$	NA	NA	NA	NA	NA	NA	NA	NA	yes +3.6%	yes +12%	no -8%	yes +6.4%
TxA Interaction				yes	yes					NA	NA	NA

T_1 = Objectives, Pretest-Remedial, Posttest
T_2 = Objectives, Posttest
T_3 = Posttest
T_4 = Control

NA= Not Applicable
yes= Significance $>.05$

[a] Let G_1 and G_2 represent the two comparison group means ($G_1 > G_2$). Then percentages calculated as follows:

Performance Measures: $G_1 - G_2$; Attitude Measures $\frac{G_1 - G_2}{5} \times 100$.

Chapter 5

Discussion and Conclusion

Inferential Stability

An examination of the hypotheses (p.30) together with Figure 11 will provide the reader with a good summary of the outcomes of this study. An estimation of the experiment's "inferential stability" will be made before conclusions are discussed.

Sir Ronald Fisher, who gave birth to the modern test of significance, believed that the standard of firm knowledge was not one significant result, but the ability to repeatedly get results at a 5% probability level. This study involved no real replication, however the posttest variables consisted of a series of seven measures of students' performance under similar conditions, thereby providing one more reliable test than the final lab performance or attitude measures.

It would be naive to expect any practical education study to be free of experimental error, especially considering the multivariate nature of a real learning environment. One serious source of error was the discovery that students in the objective groups were lending their objectives to other students. The post questionnaire administered indicated that 46% of these students lent their objectives at least once, and 17% did it often. This must be considered in the interpretation of the results.

A possible error source could have occurred during the administration of the posttests by non-vigilant lab instructors, although cheating was probably not widespread as the test scores were not used for grading purposes. In any case, this would only be a source of error when considering theoretical inferences; it is certainly a normal aspect of real learning environments.

Such factors as the Hawthorne or Experimenter Effect must be considered as possible influences on the results, especially in regard to the attitude data. Testing is also normally thought to profoundly affect what researchers are measuring. In this case, the pre and post tests were part of the instructional strategy themselves and a posttest-only group was included; therefore, this kind of error is measured, if not minimized. Indeed, these tests should be thought of as a particular type of orienting stimuli similar to the objectives.

In conclusion, the "inferential stability" of this study is reasonably high in the case of practical inferences, but low for theoretical concerns. The study was designed primarily to be of a "decision-oriented" rather than "conclusion-oriented" nature, and therefore most conclusions will necessarily be restricted to the practical viability of the technique tested. Since the "real" learning environment used for this practical test was simply too uncontrolled in regards to all variables which might influence the outcomes, the theoretical significance of this study alone would be small. However, this study will be examined together with those reported in Chapter 2 to see if any theoretical contributions can be made.

Practical Significance

If one is considering a new teaching method, it is difficult to decide what would be an acceptable magnitude of student performance gain to be considered worthwhile. Student and instructor perceptions of the technique, as well as implementation and maintenance costs would also have to be considered. In the case of providing students with behavioral objectives, the printing, distribution and administration of the method could involve relatively small amounts of energy and money, but the development of the objectives themselves is usually a many man-hour task. It might seem reasonable to assume for cost-effectiveness purposes that providing students with behavioral objectives as orienting stimuli can be recommended only if it can be demonstrated that students consistently score at least an average of 10% higher in performance measures than they otherwise would. Student and instructor attitudes should be at least as positive as the traditional strategy. This is a somewhat arbitrary decision, considering the difficulty in making any estimation of the economics of instruction at the present time, yet it is nonetheless necessary to provide a meaningful framework within which to view the results.

It must be made clear, to what population the discussions and conclusions of this study apply. Considering the sample characteristics a reasonable population referent would be college students enrolled in introductory biological science laboratories. For purposes of discussion clarity, this will be the assumed population.

Overall, the treatments did have a significant effect on student performance, but these effects were not consistent. Students provided with objectives made five or six percent gains on posttest measures compared to other groups in three of the seven weeks, although the trend can be observed in most of the weeks (see Fig. 1). It is possible that the gains would have been higher and more consistent had not the students lent their objectives to the non-objective groups. The final lab exam was one week after the conclusion of the study and the results are especially inconsistent in weeks 6 and 7, perhaps indicating that as the exam approached students began borrowing the objectives for their preparation. This could account for the general increase in the posttest scores of group no. 3

(posttest only) from weeks 5 to 7.

The posttest was not only a performance measure, it provides feedback to each student on his weekly progress as well as serving the orienting function of indicating to the student what information is important. This element of the posttest differs from elements of the objectives in that the orientation is given after instruction and is only a sample rather than a total list of criteria as was the case with the behavioral objectives.

Group no. 3, who received only the posttest, performed better than any other group in the final lab exam especially in the low ability range (see Fig. 2). This result suggests that the posttest itself was responsible for a good part of the gains achieved in treatment groups 1 and 2 who also received the same tests. This interpretation is also supported by the research of Rothkopf and Frase (1970) discussed in the next section.

Examination of Table 11 indicates that the pretest-remedial situation (ensuring adequate entering behavior) did not have any consistent effect on performance. In weeks 2, 3 and 4 where group no. 1 performed better in comparison to treatment groups 2 and 3 the gain was only slightly higher than the comparison between objective and non-objective groups, and in week 2 it was lower. These results then, do not support the usefulness of such a technique in this lab situation. Perhaps the entering behaviors specified were simply trivial; this might not be the case in other subject matters such as mathematics.

Treatment group no. 2, who received the objectives and the posttest deviated from the hypotheses' prediction on weeks 1, 5 and 6 where it scored highest of all groups and on week 7 when it was lowest. Again, the performance data do not seem to follow any clear consistent trend.

The attitude measures yielded very significant and clear differences between the treatment groups. As would be expected, the more treatment elements a group received, the greater the amount of organization perceived. The treatment groups compared to those who received no treatments thought the lab was a more satisfying experience. What was not expected was the finding that students in the treatment groups were much more critical of their lab instructors. Perhaps being "experimented upon" with new educational techniques tends to make students more critical of how their lab instructors are teaching. Group no. 3 was most critical; having a posttest alone without objectives may cause students to be critical of their instructors if they did not specifically help them attain the criteria exhibited in the posttest. In other words, students might tend to see the lab instructors behavior to be irrelevant to their performance on the posttest, which could result in a critical attitude if they accepted the posttest as a valid indication of their progress. Results obtained from the post questionnaire showed that almost all students felt the posttest to be a valuable and worthwhile indicator.

However attractive or logical the strategy of providing students with behavioral objectives as orienting stimuli may seem, these results indicate (as have the other studies reviewed in Chapter 2) that such a generally defined strategy cannot be recommended at this time as a viable educational technique, because whether or not it is effective seems to be dependent on specific properties of the learning environment in which they are used and on the form in which they are presented (pre-post, sample, total, etc.). These environmental and material organization variables have not been well researched and therefore it is impossible to specify under what conditions a set of orienting stimuli will prove beneficial. Rothkopf and Frase (1970) have done some work in this area; their work is reviewed in the next section.

These practical conclusions are made on the basis of the research reported here:

1) Developing behavioral objectives for the purpose of providing students with orienting stimuli is not advisable until further research can indicate in which settings and formats such stimuli will prove effective. Teachers who have behavioral objectives already developed for course design purposes could give them to their students, however, it would be impossible to predict with any accuracy how these orienting stimuli would effect student performance. Since simply providing students with objectives does tend to raise their scores, it would seem probable than an investigation of settings and formats would be fruitful.

2) Posttests or a small sample of orienting stimuli given after completion of a small amount of instruction will likely improve student performance significantly, especially those students who could be classified as "low ability or motivation" types. Further research is needed to firmly establish this strategy.

3) Students perceive the degree of organization in the lab environment in proportion to the number of treatment elements administered.

4) In general, students who are exposed to treatment elements in addition to the regular lab instruction tend to be more critical of their lab instructors, although they perceive the lab as more "satisfying" than otherwise.

Theoretical Significance

Wittrock (1967, p.1) notes that "the study of instruction has produced a tremendous quantity of empirical research studies, many of them without thoughtful conceptualizations, without explicit responsibility for developing a theory of instruction, and without contribution to knowledge about instruction." This study's conceptualization did not include "explicit" responsibility towards theory of development; in fact, it was centred around "behavioral objectives", the cornerstone of the technology derived from the empirical instruction model as outlined in Chapter 1.

Behavioral objectives were developed as a practical approach to the problem of measuring the difference between student entering and post-instruction behavior. The idea of giving objectives to students to help direct their behavior was essentially a logical by-product of the technology. It is now apparent that directing student behavior towards more efficient and effective processing of information is not simply a matter of "telling" the student what he should be able to do after completing an instructional sequence; there are other factors which may compete with, or support the orientation value of a behavioral objective or orienting stimuli (OSs).

Four general factors might logically be conceived to influence student behaviour: (I) personalogical characteristics of the learner (motivation, abilities, etc.), (2) general characteristics of the learning environment (noise level, lighting, etc.), (3) specific characteristics of the instructional materials and / or task, and (4) subject matter characteristics. Since giving objectives to students was hypothesized to serve the purpose of directing positive learner behaviors, it is likely that some aspects of these four factors do influence the conditions under which such OSs prove effective.

Gagne′ (1970) points out that there are certain conditions which precede the learning event itself such as attentional set and motivation which greatly influence the learner-relevant behaviors. McClelland's research (1961) indicates that students with high "need-achievement" in relation to a learning task can generally be expected to perform at a high level regardless of the state of the learning environment or instructional materials. Motivational states can be changed as a consequence of learner experience with instructional materials. Behavioral objectives can then be conceptualized as stimulus controls which can potentially produce adaptive cognitive "sets" (Hebb, 1966) which affect the attentional processes of the student. Thus manipulation of OSs could theoretically help to overcome attentional deficiencies in students who enter an instructional situation and are characterized as low "motivation", "need-achievement" or "ability" types.

Four studies (Doty 1968; Bryan and Locke 1967; Colin 1970), including this one, investigated OSs in relation to motivation or ability categories. They cannot be directly compared because of different experimental designs as described in Chapter 2, however, all except Colin found at least some evidence indicating that low ability or motivation types benefited most from the provision of OSs.

Frase and Rothkopf (1970) investigated motivation in relation to OSs in the form of questions which were imbedded in written materials after (postquestion) and before (prequestion) varying amounts of text. They concluded that these questions had arousal and associative outcomes and that postquestions which occurred after small amounts of text were especially useful for low motivation students. They varied the incentive by using different schedules of pay-off for correct responses on a post test. This supports the hypothesis that OSs are not as important for highly motivated learners because they enter the instructional task with an already strong and persistent "attentional set". Future sophistication in OSs use might also lead to significant gains for highly motivated students.

Three studies (Tiemann, 1965; Bryan and Locke 1967), including this one, used attitude measures. All indicated that students provided with OSs acquire more positive attitudes towards the instruction, excepting as reported here, in regards to instructor effectiveness. It is evident, then, that personological variables are important when considering OSs use; further research in this area might well prove valuable.

Rothkopf and Frase (1970) also investigated OSs in relation to specific characteristics of instructional materials. They postulated that manipulation of OSs (questions) affect the inspection activities of the student and that these in turn determine what is learned. For example, the difference between the effects of placing a question before or after a small amount of text are explained in terms of attention and reading variables. After reading a prequestion a student rapidly scans the text for the relevant information. If the same question is placed after the text, the student reads the text as normal, then may even review the text for the relevant material. Students using postquestions generally achieved the criteria defined as well as the prequestion group, however, on measures of incidental information their scores were always higher reportedly due to the more careful reading and greater amount of "search activity" which resulted from the postquestion arrangement. The finding that low incentive groups especially benefited from postquestions as compared to prequestion groups could be explained by postulating that such students are especially prone to scanning the material quickly if allowed to (principle of least effort, Underwood, 1963).

The position of the OS or OS set in regard to the instructional materials was not clearly indicated in reports of those studies reviewed in Chapter 2. All provided students with OSs before instruction as well as OSs in the form of posttests to evaluate student learning. Such posttests can be considered as having an orienting function, especially if they are frequent rather than administered after large amounts of instruction. Some studies, this one included, gave the OSs to students on separate sheets in the form of lists, others may have embedded the OSs in the instructional materials. The position of the OSs in the instructional material would seem to be another important consideration.

A behavioral objective is by definition <u>specific</u>, that is, relating to a small information chunk and <u>behavioral</u> in that it implies or specifies an acceptable post-instruction student behavior. It is only one kind of OS potentially available for use. OSs can vary along a general-specific dimension, include behaviors or not, or even appear in non-verbal form, such as underlining and page lay-out.

The type of OSs used in the reported studies varied. More than half used behavioral objectives and as well as specific OSs others used more general forms such as "general goals" (Tienman 1965),"task-related instructions" (Yelon and Schmidt, 1971) and "rules" (Merrill, 1971). Three studies (Mager and McCann, 1961; Allen and McDonald, 1963; De Rose, 1968) also allowed students provided with objectives access to an instructor or an individual basis when needed, thereby providing students with potential verbal OSs from the instructor. In all cases the medium used to express the OS was written sentences except for the potential verbal orientation in the three studies mentioned above. It is quite likely that all the studies to date have included in their learning task or environment other implicit OSs which could have influenced student behavior.

The subject matter used in these reported studies varied from simple addition or calculations (Doty 1968; Bryan and Locke 1967) to complex cognitive tasks such as used by Merrill (1971). If we use Blooms (1956) taxonomy as a reference, the combined subject matter of these experiments provides a good sample of content ranging from simple to complex. None of the experiments actually categorized the subject matter in this specific manner, therefore it is not possible to rank the complexity of the subject matter of these experiments on a simple-complex basis. However, the extremes can be compared to see if any trends emerge.

Doty used identification and calculation of resistor magnitudes as his task, Bryan and Locke studied the effect of OSs using simple addition, and the subject matter of the author's study could, as well, be categorized predominately in Bloom's lower taxanomic levels, even though a somewhat greater variety of cognitive abilities was required. All of these studies reported some gains in the groups provided with objectives, especially in those with the low ability student. The remaining studies showed advantages for the specific objective groups on measures of immediate learning in the case of independent study and only for time saving not performance level. For example, Colin (1970) used grade seven science and De Rose (1968) used high school science subjects; both found no significant difference between the objective-nonobjective groups. The only study in which some students provided with objectives actually performed at a lower level than otherwise is reported by Yelon and Schmidt (1971). They deliberately picked a task which could be categorized as complex. One tentative trend then, is that specific OSs seem to prove more beneficial with simple factual subject matter than with complex materials.

The research reported by Frase did not concern itself directly with the question of subject matter complexity, in fact, Frase admits (1970, p.341) that most of the questions employed were of a factual nature related to relatively simple subject matters. His distinction between relevant information (that information in the text to which instructional objectives or criterion items relate) and incidental information (information not necessary to achieve criteria) does, however, provide one explanation of the subject matter trend outlined earlier. In the use of complex subject matter it is difficult to decide when formulating OSs which information is relevant. If the OSs is a behavioral objective (or any specific OS) chances are good that the instructor will classify some relevant information as incidental simply because he cannot reliably tell whether a "piece" of information is incidental or not. Kibler (1970, p.100) points out the general tendency that the percentage of observable behavior is inversely related to grade level, that is, he believes that objectives for a child of kindergarden age involve considerably less complex skills than objectives for a graduate student course. Returning to Bloom's taxonomy, we would expect, then, that it is difficult to specify complex behavioral objectives because the criteria behaviors are not obvious. It is postulated, then, that it may be dangerous to provide students with <u>specific</u> orienting stimuli for complex instructional materials as such OSs are likely to focus the students' attention and resulting inspection activities on a limited amount of information which may not be sufficient to achieve the instruction goals. This interpretation could account for the tendency described earlier for specific OSs to prove most effective with simple factual material.

A logical corollary of the above discussion is that <u>general</u> OSs (questions or objectives which orient the student towards relatively larger chunks of information) should prove to be more effective for complex subject matters than a specific OS. Yelon and Schmidt (1971) provided one group of students with specific objectives and another with more general OSs in the form of "task-related instructions" for the complex cognitive task required. Students with specific objectives did not exhibit performance gains as a result; in fact in some cases their performance was lowered. The general OS group did exhibit some significant performance gains. Merrill (1971) used objectives and rules to direct student behavior in learning an imaginary science. He concluded that objectives did not contribute much to improving student performance when the rules were also used. This data supports the contention that such specific OSs as behavioral objectives are most useful for simple material but that complex material requires more general orienting stimuli.

In the light of this discussion, the studies on the use of behavioral objectives as orienting stimuli were poorly conceptualized in regards to potential theoretical contributions. They did provide unwittingly, however, some additional support for the interpretations Frase and Rothkopf made of their own studies as well as employing a variety of subject matter which illustrated the importance of subject matter complexity in the consideration of OSs. No firm conclusions can be made; however, it is obvious that the wide variability in the outcomes of the studies done to date cannot be explained adequately by any existing theoretical framework. If further experimentation is carefully designed to measure personological, subject matter, and other possible related variables, then it is much more likely that a useful theory will be derived.

Recommendations for Further Research

The research reported here clearly indicates that decision-oriented research on the effect of behavioral objectives as orienting stimuli will have limited future value. Further research should concentrate on testing and further elaboration of the theoretical frameworks associated with activities which determine the nature of the effective stimuli in experimental or instructional situations. The effects of orienting stimuli on student learning are not simple; it is unlikely that an effective practical strategy will be discovered without further investigation and theory building.

Investigators should not constrict themselves to behavioral objectives or questions as orienting stimuli. Underlining, page lay-out, color coding and other orientation mechanisms should be studied. Experiments need to be carried out on different complexities of subject matter using a wide range of specific and general orienting directions. An orienting stimuli classification system needs to be developed as well as a further multivariate analysis of total learning environments for orientation components.

Appendix A

Pretest Sample - Exercise no.17

Pre-test Exercise No.17

1. The structures associated with the movement of ova from their production to their fertilization are listed below. What is the correct sequence?

   A) ovary - vagina - uterus - fallopian tube

   B) ovary - fallopian tube -

   C) ovary - uterus - vagina -

   D) oviduct - uterus - vagina -

   E) uterus - fallopian tube -

   1) AB

   2) BD

   3) A

   4) CD

   5) D

2. Pick the answer which <u>best</u> describes the movement of the sperm from synthesis to impregnation of the female.

   A) testis - vas deferens -

   B) testis - seminal vesicle -

   C) seminal - vesicle - urethra - penis

   D) testis - epididymis - vas deferens -

   E) testis - epididymis - penis

1) AC

2) BC

3) DC

4) E

5) CD

3. Which answer describes best the components of the appendicular skeleton?

   1) pelvic girdle, hind limbs, rib cage, forelimbs

   2) skull, vertebral column, rib cage

   3) vertebral column, hind limbs, pelvic girdle, forelimbs

   4) forelimbs, pectoral girdle, hindlimbs, pelvic girdle

   5) rib cage, vertebral column, pelvic girdle

4. The term homology means:

   1) Similarity of structure between two different organisms.

   2) Similarity of development of structures between two different organisms.

   3) Similarity in embryonic development and adult structure, indicative of common evolutionary ancestry.

   4) An inference that if two or more things agree in some respects, they will probably agree in others.

   5) None of the above.

5. Which of the following statements best describes the proximal function of the adrenal gland:

1) Production of ACTH
2) Production of insulin
3) Production of adrenalin and noradrenalin
4) Production of sex hormones
5) Production of adrenalin, noradrenalin, sex hormones and others

Appendix B

Sample List of Behavioral Objectives - Exercise no.17

A OBJECTIVES FOR EXERCISE NO.17

URINO-GENITAL SYSTEM

I FEMALE URINARY SYSTEM:

1) You must be able to label on your diagram and locate in your rat specimen, the following structures:

a) kidney

i) cortex

ii) medulla

b) ureters

c) urinary bladder

d) urethral opening

e) clitoris

2) You must be able to state the proximal functions of the 5 structures mentioned above.

II FEMALE REPRODUCTIVE SYSTEM:

1) You must be able to label on your diagram and locate in your rat specimen, the following structures:

a) ovaries

b) Fallopian tube

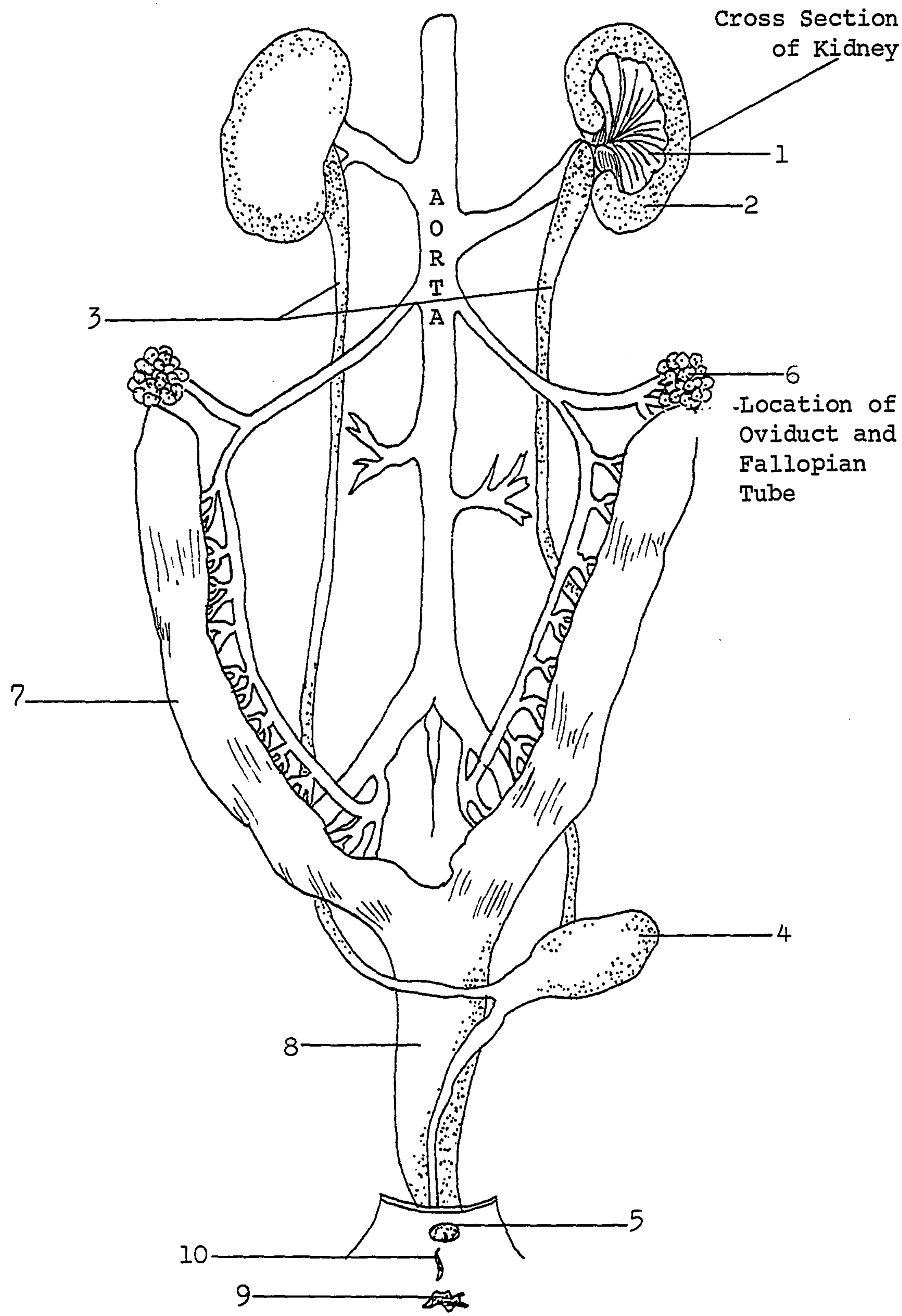
c) oviduct

i) uterus

d) vagina

e) vaginal opening

Female Urogenital System



2) You must be able to state the proximal function of the above mentioned structures.

*3) You must be able to describe in writing how the uterus becomes prepared for pregnancy.

*4) You must be able to trace, with words, the movement of ova from their production to their fertilization; naming structures associated with each step.

*5) You must be able to state the proximal function of the adrenal gland.

III <u>MALE URINARY SYSTEM</u>:

1) You must be able to label on your diagram and locate in your specimen the following structures.

a) ureter

b) bladder

c) urethra

d) penis

IV <u>MALE REPRODUCTIVE SYSTEM</u>:

1) You must be able to label on your diagram and locate in your specimen, the following structures:

*a) scrotal sack

*b) testes

c) epididymis

d) vas deferens

*e) vesicula seminalis

f) urethra

g) penis

2) You must be able to state the proximal functions of the above mentioned structures which have been marked with an asterisk (*).

3) You must be able to locate and label the following structures which are associated with the reproductive system of the male rat:

a) coagulating gland

b) glands of the vas deferens

c) prostate gland

*d) gaubernaculum

*e) spermatic cord

4) You must be able to state the function of the above mentioned structures labelled with an asterisk (*).

*5) You must be able to trace with words the movement of the sperm from synthesis to impregnation in the female.

B SKELETAL SYSTEM

*1) You must be able to list, in the following manner, the two major divisions of the skeletal system of the rat and the components of each division:

a) Axial Skeleton:

i) skull

ii) vertebral column

iii) rib cage

b) Appendicular Skeleton:

i) pelvic girdle

ii) hind limbs

iii) pectoral girdle

iv) forelimbs

2) You must be able to write out at least two examples of skeletal adaptations of four-limbed vertebrates to different forms of locomotion.

I AXIAL SKELETON

1) Skull:

a) You must be able to state that the skull is divided into the 5 following subdivisions:

i) cranium

- occipital condyles

ii) nasal capsule

iii) otic capsule

iv) secondary palate (not in diagram)

v) jaws

- upper jaw
- lower jaw

*- massater muscles (not in diagram)

*- incisor teeth

*- molar teeth

*Note: The last 3 structures are not actually part of the skull but are presented here for organizational simplicity.

2) Vertebral Column:

a) You must be able to state the 5 different categories of vertebrae in the rat.

3) Rib Cage:

a) You must be able to state to which two structures each rib is attached.

II APPENDICULAR SKELETON

1) Pelvic Girdle:

a) You must be able to state whether the pelvic girdle is attached to the vertebral column or not

b) You must be able to list the important structures of the pelvic girdle as:

i) sacral vertebrae

ii) ilium

iii) acetabulum

2) <u>Hind limbs</u>:

a) You must be able to list the following bones which make up the hindlimb:

i) femur

ii) tibia

iii) fibula

iv) tarsal

v) metatarsals

vi) phalanges

3) <u>Pectoral Girdle</u>:

a) You must be able to state whether the pectoral girdle is attached to the vertebral column or not.

b) You must be able to state the important structures of the pectoral girdle as:

i) scapula

ii) clavicle

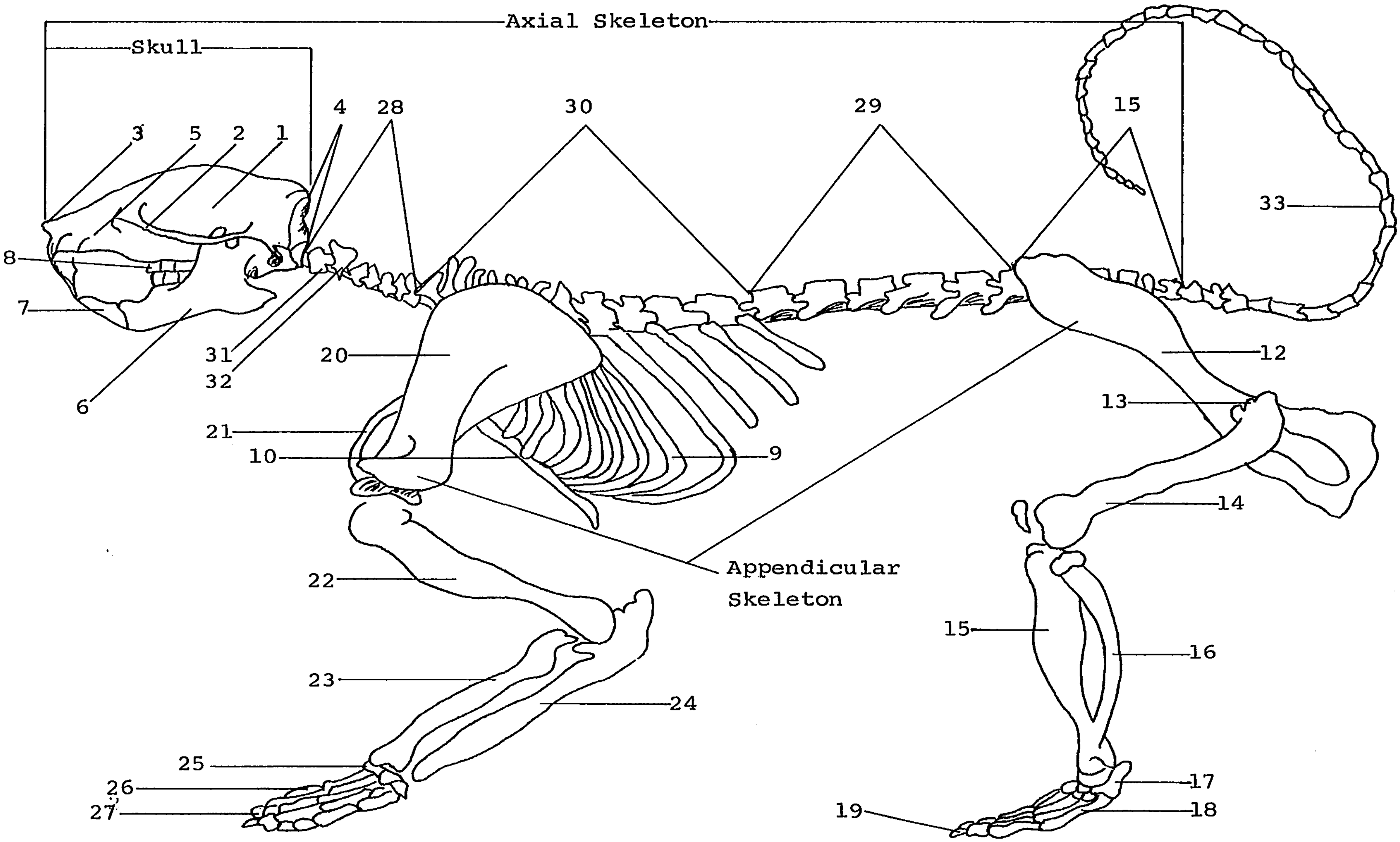
iii) glenoid socket

4) <u>Forelimbs</u>:

a) You must be able to list the following bones which make up the forelimb :

i) humerus

Skeletal Features Of Rat



ii) radius (rats are a R.I.O.T. - Radius is Opposite Thumb)

iii) ulna

iv) carpals

v) metacarpals

vi) phalanges

C FUNCTIONAL AND ADAPTIVE ASPECTS OF THE SKELETAL SYSTEM

*You must be able to define the terms homology and analogy according to your Weisz textbook.

I AXIAL SKELETON

1) You must be able to state the proximal function of the following structures which are associated with the skull:

a) cranium

b) nasal capsule

c) otic capsule

d) occipital condyles

e) secondary palate (not on diagram)

f) lower jaw

g) molar teeth

h) incisor teeth

2) You must be able to state the way in which the above mentioned structures have become adapted for their particular function.

e.g. Cranium: proximal function is to enclose the brain but in the rat it shows an adaptation by being large to accommodate the advanced mamallian brain.

3) You must be able to state the proximal function of the atlas and the axis.

4) You must be able to state the proximal function of the following structures:

   a) centrum (not in diagram)

   b) tall crests on cervical vertebra

   c) neural arch

   d) zygophyses

5) You must be able to state the main function of the ribs as indicated in the laboratory manual.

II APPENDICULAR SKELETON

1) You must be able to state the proximal function of the following structures:

   a) pectoral girdle

   b) scapula

   c) glenoid socket

   d) wrist joint

2) You must be able to state the proximal function of the following structures:

   a) pelvic girdle

   b) sacral vertebrae

   c) ilium

   d) adetabulum

Appendix C

Sample Posttest - Exercise no.17

Posttest Exercise 17

Below are given two lists A and B.

A	B
kidney	ovaries
ureters	fallopian tube
urinary bladder	oviduct
urethral opening	vagina
clitoris	vaginal opening

For each of the two questions below you must decide whether the proximal functions listed contain more from A or B. If there are more from list A blacken in (1) on your card. Likewise if there are more from list B blacken in (2). If both are equally represented mark (3).

1)

1) Filtration of waste material from the blood
2) Passage of ova to area where it is fertilized
3) Storage of waste products filtered out in the kidney
4) Opening which allows sperm to be introduced to ova
5) Site of production of ova

2)

1) Tubes conducting urine from kidney to urinary bladder

2) Pathway of ova from ovary to oviduct

3) Opening for emission of waste material from the kidney

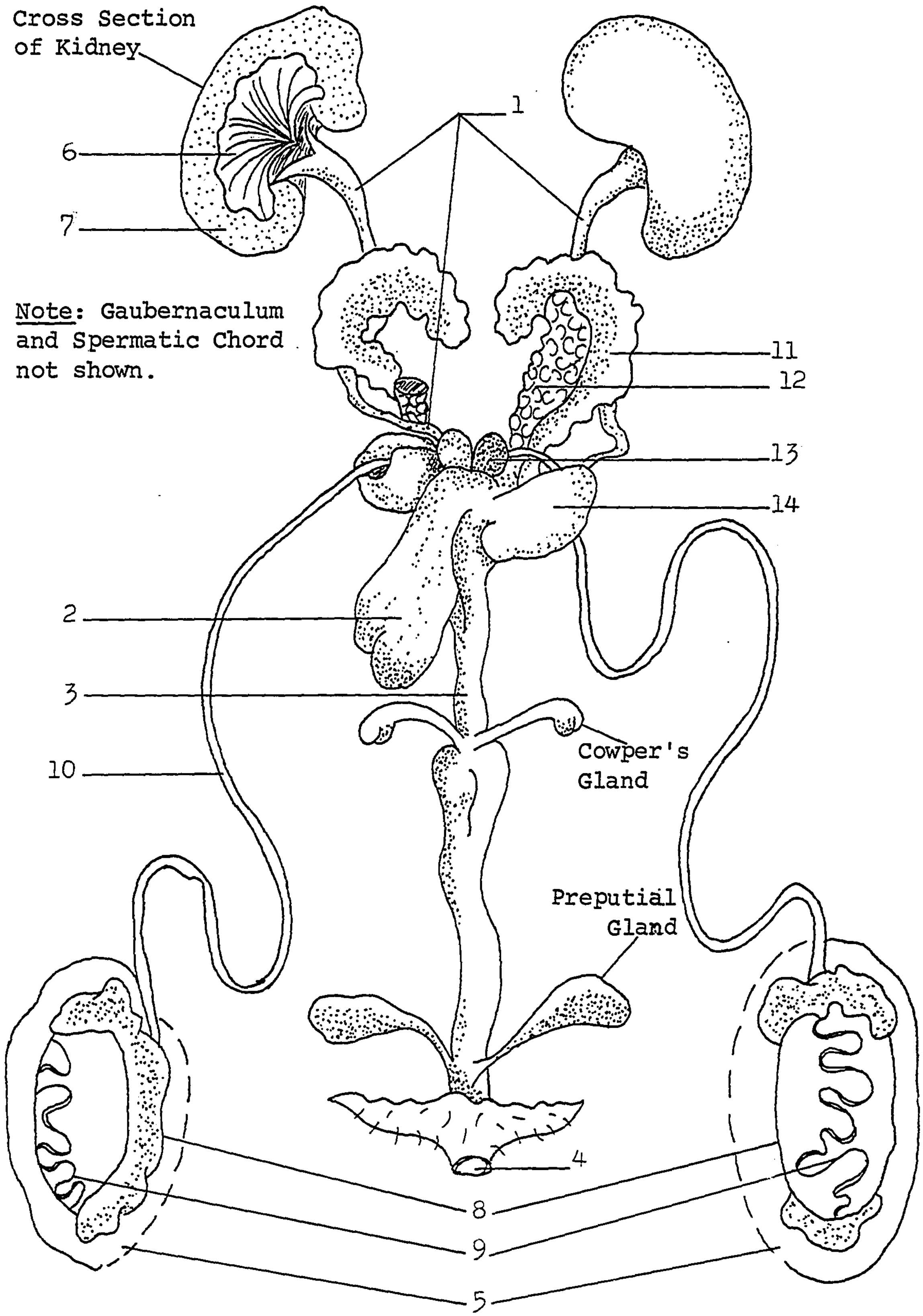
4) Production of FSH

5) Production of adrenalin

Using the enclosed diagram answer the following questions concerning the male urogenital system.

3) Label 1 refers to:	1) vas deferens
4) Label 2 refers to:	2) urinary bladder
	3) epididymus
	4) vesicula seminalis
	5) ureters
5) Label 6 refers to:	1) kidney cortex
6) Label 11 refers to:	2) kidney medulla
	3) coagulating gland
	4) prostate gland
	5) vas deferens gland

Male Urogenital System



7) Label 9 refers to: 1) testis

8) Label 10 refers to: 2) epididymus

3) vas deferens

4) urethra

5) spermatic cord

9) Which of the following lists best describes the components of the skull?

1) cranium, vertebrae, sternum

2) otic capsule, cervical vertebrae, incisor teeth

3) otic capsule, nasal capsule, cranium

4) nasal capsule, scapula, atlas

5) atlas, axis, cranium

The following four questions are True-False. If True blacken in (1). If False blacken in (2).

10) The nasal capsules have become adapted to enhance the protection of the olfactory sensory apparatus.

11) The lower jaw has become adapted by becoming heavier and thus maintaining the mouth in the open position in order to facilitate fly-catching.

12) The occipital condyles have become adapted to allow attachment of the large neck muscles which are needed to keep the head off the ground.

13) The proximal function of the pectoral girdle is to allow firm support and attachment for the forelimbs.

14) Which of the following best describes the hindlimb?

1) tibia, scapula, clavical
2) ilium, tarsal, acetabulum
3) femur, phalanges, tarsal, fibula
4) tarsal, humerus, ulna
5) metatarsal, genoid socket, radius

Appendix D

Lab Evaluation Questionnaire

Lab Evaluation Biology EIO

Lab Section: ________________ Time: ____________________

This questionnaire is to measure your reactions to the laboratory periods given in the second term only (1970). Please answer all questions carefully so that the data we receive will enable us to improve the laboratories.

All answers are to be recorded on the IBM card provided using the pencil provided. Be sure to blacken the appropriate spot thoroughly. Your lab section and time (day, P.M. or A.M.) should be printed carefully on BOTH the IBM card and the questionnaire.

I LAB ORGANIZATION

Rate the following aspects of lab organization on a 1-5 scale.

1. objectives clear	1	2	3	4	5	objectives unclear
2. well organized	1	2	3	4	5	confused
3. stimulating	1	2	3	4	5	boring
4. worth attending	1	2	3	4	5	useless
5. content good	1	2	3	4	5	content bad

II CHARACTERISTICS OF LAB INSTRUCTOR

	Bad				Good
6. he interprets ideas and theories clearly	1	2	3	4	5
7. he makes good use of examples and illustrates	1	2	3	4	5

8. he has made the material interesting 1 2 3 4 5

9. communicates his enthusiasm to the class 1 2 3 4 5

10. is available for personal help 1 2 3 4 5

11. is well prepared for class 1 2 3 4 5

12. his teaching is effective 1 2 3 4 5

13. his presentations are stimulating 1 2 3 4 5

14. deals with student questions adequately 1 2 3 4 5

Other Comments

____

____

III <u>SATISFACTION WITH LABORATORY COURSE</u>

15. I was very interested in this field of study	1	2	3	4	5	I am not interested in this field of study
16. This course is very relevant to my personal goals	1	2	3	4	5	This course is very irrelevant to my personal goals
17. I will be taking more senior courses in this field	1	2	3	4	5	I will not be taking more senior courses in this field
18. This laboratory has had a great impact on me	1	2	3	4	5	This laboratory has had no impact on me

19. My expectations of the lab were met 1 2 3 4 5 My expectations were not met

20. I would recommend this course to my friends 1 2 3 4 5 I would not recommend this course to my friends

21. Overall, I am extremely satisfied with labs 1 2 3 4 5 Overall, I find the labs very unsatisfactory

IV <u>RECOMMENDED CHANGES FOR THE LABORATORY</u>

22. Work load should be decreased 1 2 3 4 5 Work load should be increased

What suggestions can you make for the improvement of teaching in the laboratory?

____

____

V <u>EVALUATION OF LAB EVALUATION QUESTIONNAIRE</u>

23. How confident do you feel your answers to the above structured questions reflect your true feelings about the laboratory work? Very Well 1 2 3 4 5 Poorly

Please comment on any aspects of the laboratory omitted in this questionnaire.

____

____

TO HELP US EVALUATE THE NEW METHODS TRIED PLEASE COMPLETE THE FOLLOWING AS CAREFULLY AS POSSIBLE. OMIT ANY SECTIONS WHICH DON'T APPLY TO YOU. WE WOULD APPRECIATE YOUR WRITTEN COMMENTS.

PRETEST - REVIEW SESSION

Comment on the pretest on a 1-5 scale using the following guidelines:

24. The knowledge gained from preparing for the pre-test was useful for the lab exercise

1 2 3 4 5

Useless — Very Valuable

25. On the average I spend 1 2 3 4 5

5min. ½hr. 1hr. 1½hr. 2hrs.

preparing for the pretest.

26. Overall, I would rate the value of the pretest

1 2 3 4 5

Low — High

OBJECTIVES

Rate the following characteristics of the objectives

27. Diagrams 1 2 3 4 5

28. Introduction (background info.) 1 2 3 4 5

29. Organization 1 2 3 4 5

Useless — Extremely Valuable

Rate the following on a 1-5 scale along the dimension of agree-disagree.

	Strongly Disagree 1	2	3	4	Strongly Agree 5
30. I found the objectives useful when doing the lab exercise.	1	2	3	4	5
31. I would like to see all students in labs provided with objectives	1	2	3	4	5
32. Objectives are useful for study purposes	1	2	3	4	5
33. The objectives themselves were clearly written and easily comprehensible.	1	2	3	4	5
34. I often gave my objective sheets to other students who wanted them but who were not provided with them (mark 1 if you never lent your objectives).	1	2	3	4	5
35. Overall, I would rate the availability of such objectives as very valuable for learning purposes	1	2	3	4	5

Comments ______________________________

____

REVIEW SESSION

	Useless 1	2	3	4	Very Valuable 5
36. Overall, I would rate value of the review session (for those who failed pretest) as	1	2	3	4	5

37. I attended:

1	2	3	4	5
No review sessions	1 review session	two	three	four or more

POSTTEST

	Strongly Disagree 1	2	3	4	Strongly Agree 5
38. The posttest was valuable as an indication of how well I was doing the lab exercise.	1	2	3	4	5
39. I checked my marks on the posttest each week.	1	2	3	4	5
40. Overall, the posttest was very valuable.	1	2	3	4	5

Appendix E

Standard Deviations

Table 1 - Posttest

Table 2 - Final Lab Exam

Table 1
Posttest: Standard Deviation Scores

Treatment	Ability Levels	N	Standard Deviation Scores						
			W_1	W_2	W_3	W_4	W_5	W_6	W_7
(T_1) Objectives	Lo (A_L)	24	14.4	16.9	13.3	8.7	16.4	15.1	16.7
Pretest-Remedial	Med (A_M)	23	19.8	16.2	24.1	9.0	14.5	17.4	15.1
Posttest	Hi (A_H)	22	19.8	16.3	7.0	14.0	12.1	15.4	23.3
(T_2) Objectives	Lo (A_L)	22	13.8	10.2	17.0	12.5	13.0	11.9	20.9
Posttest	Med (A_M)	26	12.2	16.0	8.9	14.9	10.4	17.4	23.2
	Hi (A_H)	35	16.3	16.7	8.9	9.3	10.7	14.8	22.0
(T_3) Posttest	Lo (A_L)	22	19.1	10.5	19.3	9.9	12.1	17.4	15.3
	Med (A_M)	33	11.6	17.4	9.9	9.4	16.9	15.2	13.4
	Hi (A_H)	29	14.8	13.8	13.6	15.5	12.8	14.2	17.4

Each standard deviation in Table 1 represents the standard deviation of subjects receiving treatment T_i, having an ability level category of ability A_j (Low, Medium, High) on a posttest administered during week W_k (W_1 – W_7). The design denotes seven measures of each subject's performance.

Table 2
Final Lab Exam: Standard Deviation Scores

Treatment	Ability Levels	N	Standard Deviation
(T_1) Objectives Pretest-Remedial Posttest	Lo (A_L)	24	9.0
	Med (A_M)	22	8.6
	Hi (A_H)	22	6.1
(T_2) Objectives Posttest	Lo (A_L)	23	10.3
	Med (A_M)	26	7.4
	Hi (A_H)	33	6.4
(T_3) Posttest	Lo (A_L)	22	9.7
	Med (A_M)	35	7.7
	Hi (A_H)	29	5.5
(T_4) Control	Lo (A_L)	88	11.2
	Med (A_M)	103	7.3
	Hi (A_H)	90	6.7

Each standard deviation in Table 3 represents the standard deviation score on a final lab exam of subjects receiving treatment T_i , having an ability level category of A_j , (Low, Medium, High).

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