The purpose of this study was to determine the effects of providing behavioral objectives prior to instruction on the achievement of students in a one-semester college general chemistry course and to determine the effect of providing behavioral objectives of selected chemistry experiments in the acquisition of achievement associated with laboratory work.

The population consisted of 244 students enrolled in 12 sections of General Chemistry 102 at Chulachomklao Royal Military Academy, Nakornayok, Thailand, during the second semester of 1990.

Twelve sections were assigned at random to three different treatments and one control group. Students in group I received behavioral objectives for both classroom
and laboratory instruction. Students in group II received behavioral objectives for classroom instruction and non-behavioral objectives for laboratory instruction. Students in group III received non-behavioral objectives for classroom instruction and behavioral objectives for laboratory instruction. The control group received non-behavioral objectives for both classroom and laboratory instruction. A list of behavioral objectives at cognitive level was distributed to each student prior to the beginning of each unit during two four-week units of study.

A one-way analysis of covariance was used to analyze the achievement test scores. Scheffe's test was used for multiple comparisons. The 0.05 level was used to determine the significance of the results. There was a significant difference in achievement between students in group I and the control group. There was a significant difference in achievement between students in group II and the control group. There was a significant difference in achievement between students in group III and the control group.

It was concluded that providing students with behavioral objectives prior to instruction did significantly enhance achievement in chemistry, as compared with providing students with non-behavioral objectives prior to instruction in both classroom and laboratory instruction. This conclusion was limited to the Chulachomklao Royal Military Academy, Thailand and any similar situation and groups that may exist.
The Effects of Behavioral Objectives on Student Achievement in College Chemistry

by
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A THESIS
submitted to
Oregon State University

In partial fulfillment of the requirements for the degree of
Doctor of Philosophy

Completed February 20, 1991
Commencement June, 1991
APPROVED:

Redacted for Privacy

Professor of Science Education and Education in charge of major

Redacted for Privacy

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Date thesis is presented February 20, 1991

Typed by Pravate Mongkolsiri for Pravate Mongkolsiri
ACKNOWLEDGEMENT

I am deeply grateful to my advisor, Dr. Thomas P. Evans, for his patience, advice, support and encouragement throughout five years and a half of my study at Oregon State University.

Sincere appreciation is extended to the members of my doctoral committee: Dr. James H. Krueger, Dr. Karl J. Nice, Dr. Allen F. Anglemier, Dr. Wilbert Gambles, and Dr. Sonia R. Anderson. Special thanks and sincere appreciation go to the Royal Thai Army and Chulachomklao Royal Military Academy for their scholarship.

This study would not have been possible without the willing cooperation and professional assistance of the following Chulachomklao Royal Military Academy chemistry instructors: Col. Lt. Dr. Soraj Pechsiri, Col. Dr. Khunta Sanganete, Maj. Ohsoj Pavilai, Capt. Pattananya Lekhawat, Capt. Pichai and Capt. Sompong Wanakot. Special thanks go to Col. Somchart Chounviset, chairman of chemistry department.

A special note of thanks to Capt. Pattananya Lekhawat for her help to prepare all Thai version instruments. I also wish to express appreciation for Prapaisri, whose help for statistical analysis.
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THE EFFECTS OF BEHAVIORAL OBJECTIVES ON STUDENT
ACHIEVEMENT IN COLLEGE CHEMISTRY

CHAPTER I

INTRODUCTION

One of the primary goals of instruction is to maximize the learning of prescribed content in a unit of study. Through the years, educational researchers have attempted to discover techniques of instruction which make learning effective and efficient. One instructional technique is to focus the attention of the learners on the content to be learned by informing them of the objectives of the unit. There has been much emphasis on the use of behavioral objectives since the publication of Mager's Preparing Objectives for Programmed Instruction (1962), both on the part of instructors preparing lesson plans, and those designing instructional units meant to be self contained. Theoretically, informing learners of the objectives should aid learning: the learners are made aware of what is to be learned, and as they proceed through the new material, they are able to monitor their progress toward the objectives. Although it is generally accepted that objectives are important for instructors so that the instructional content and evaluation are unified, and although the use of
objectives have been incorporated into various models of instructional design, informing the learners of what they are expected to learn is not uniformly practiced. Furthermore, empirical research has shown ambiguous results concerning the effectiveness of providing learners with objectives prior to learning.

During the last two decades, the effects of performance or behavioral objectives on learners have been extensively investigated. Many research variables have been considered, such as whether or not the objectives are presented to the learner, whether or not the learner understands them, location of the objectives in the lesson, type of text material, type of learning outcomes, and forms of the objectives. Several reviews of these studies have been conducted during the last two decades (MacDonald-Ross, 1973; Duchastel & Merrill, 1973; Melton, 1978; Hartley & Davies, 1976; Lewis, 1982a). None of these reviewers reached a conclusion about whether or not learning is enhanced by the use of objectives. Several researchers have recommended that objectives continue to be used, since they are not harmful and may be helpful. In addition, results of 39 studies which examine the influence of behavioral objectives on student achievement in science were found to be inconsistent and inconclusive. Furthermore these results suggested that there was a need to conduct more research on the effects of behavioral objectives on learning.
Rationale and Theoretical Framework of the Study

The theoretical framework for the study was drawn from four areas. These four areas are as follows:

1. Roles of behavioral objectives in instruction and learning.
2. Stated advantages of behavioral objectives.
3. Findings of related research.
4. Background of the problem.

Each of these areas is discussed in the following paragraphs.

Roles of Behavioral Objectives in Instruction and Learning

Definition

Behavioral or performance objectives are precise statements of what the learners will do as a result of instruction. Presumably, this performance, behavior, or attitude represents a change affected by the instruction; i.e., "something" is to be learned. The objective is thus closely related to a learning outcome. Several terms have been used to describe this kind of objective such as behavioral, performance, or instructional objectives. Although there are fine distinctions in meaning among these terms, all are meant to emphasize the fact that the learners
perform some behavior which can be observed, and based upon
this behavior or performance, someone can objectively
evaluate whether or not the behavior can be performed. All
are "operationally defined objectives" (Gagne & Briggs,
1979).

Because one of the main functions of the objective is
to communicate among various participants in the educational
process, clarity is stressed by objectives advocates. One of
the earliest and best known forms is that proposed and
described by Mager in his influential and practical "how to"
book published in 1962, Preparing Instructional Objectives,
Magerian objectives have the following three components: (1)
performance, (2) condition under which it is performed, and
(3) criterion for acceptable performance (Mager, 1962).

**Main function**

There are basically three main functions of objectives:
(1) the use of objectives in designing or planning
instruction, incorporated into several instructional design
models (Tyler, 1950; Gagne, 1977; Gagne & Briggs, 1979;
Briggs & Wagner, 1981); (2) a step in the learning process;
that is, informing the learner what the objectives are; and
(3) for monitoring student progress. Although these three
categories are related, the main focus of this study will be
on the second function.
In the Designing of Instruction

Tyler (1950) states that, "Education is viewed as the process by which desirable changes are made in the behavior of the students using behavior in the broad sense to include thinking, feeling and acting" (p.5). According to Tyler, the overall planning for educational activity involves four fundamental questions which must be answered when developing any instruction and curriculum. These are as follows:

1. What should be the educational objectives of the curriculum?

2. What learning experiences should be developed to achieve the objectives?

3. How should these learning experiences be organized to increase their cumulative effects?

4. How should the effectiveness of the curriculum be evaluated?

According to Forgarty (1976):

Tyler's four questions translate into a linear model that begins with objectives and then proceeds to the selection of learning experiences based on these. The next step is to organize learning experiences for maximum effectiveness and the last is to evaluate (p. 28).

While Forgarty translated Tyler's questions into a linear model, Merrill (1971a) has described the process laid
down by Tyler as cyclic in nature, since the objectives
determine learning experiences which in turn determine the
evaluation items. The feedback obtained from evaluation
leads to modification in objectives, and so on.

While emphasizing the role of behavioral objectives in
planning and evaluating learning, Sullivan (1971) has
emphasized three basic elements of Tyler's model in terms of
what teachers want to know about the instruction and
instructional material. According to Sullivan, these
elements include the following:

1. Teachers want to know what learning outcomes are to
   be acquired by students from a program of instruction;

2. Teachers require instructional materials and
   procedures that enhance the achievement of these outcomes in
   as efficient a manner as possible; and

3. Teachers want to acquire efficient means for
determining whether or not their students have achieved the
learning outcomes.

Objectives are critical to the design and development
of instruction, according to Dick and Carey (1985, p.98),
because they are used in designing tests, developing and
selecting instructional material, and revising material.
MacDonald-Ross, in his review (1973), also mentions their
value in planning, choice of instructional material, and
evaluation.

A review of these models reveals that the objectives of
a unit of instruction should be specified before the instruction starts. They are an important prerequisite for effective instruction and learning.

Objectives and the Learner

In addition to using objectives in the systematic design of instruction, "stating the objectives to the learner" is incorporated into many instructional design models (Gagne, 1977; Gagne & Briggs, 1979; Briggs & Wagner, 1981). This practice has been referred to as a preinstructional strategy. Such strategies, which also include overviews, pretests, and advanced organizers (Hartley & Davies, 1976), are steps occurring before the body of the lesson or unit, which cue the learners about what is coming in the lesson.

A number of learning theories were introduced during the 1960's. These include those proposed by Gagne (1965), Ausubel (1963), and Bruner (1956). Many of these theories allude to the value of providing some knowledge of goals prior to instruction. Of particular interest, Gagne (1965), proposed that the educator should provide the students with goals (behavioral objectives) which would allow the students to organize their own learning activities, and help to eliminate rote memorization.

Ausubel (1963) believes that reception learning plays a
major role in the instructional process in spite of his recognition of the importance of discovery and inquiry techniques. In his theory of meaningful reception learning Ausubel distinguishes between meaningful reception and rote reception learning. Rote reception learning occurs when new knowledge cannot be associated with concepts that are already a part of the learner's cognitive structure. Meaningful reception learning occurs when new knowledge is associated with concepts in the learner's cognitive structure. According to Ausubel, after new information is meaningfully acquired, a process referred to as "obliterative subsumption" occurs. In this process subsuming concepts facilitate the acceptance of new information into the learner's cognitive structure. In instructional areas where prior cognitive structure do not have subsumers available, Ausubel hypothesizes that "advance organizers" can facilitate learning. Therefore learning should be enhanced whenever new material presented in advance in the form of behavioral objectives can be related to concepts that the learner already possesses.

Gagne and Briggs (1979, p.157) incorporate "informing the learner of the objectives" into their nine-step model:

1. Gaining attention
2. Informing the learner of the objective
3. Stimulating recall of prerequisite learning
4. Presenting the stimulus material
5. Providing "learning guidance"
6. Eliciting the performance
7. Providing feedback about performance correctness
8. Assessing the performance
9. Enhancing retention and transfer.

These instructional events are external to the learner, and, according to the authors, should be considered for incorporation into the instruction. However, they mention that all events do not need to occur for every lesson, since one or more of them may be obvious to the learner, or the learner may be a sophisticated "self learner," and may not need much external guidance (p.123).

The Gagne and Briggs model for instructional design is based upon cognitive learning theory and the information processing model of learning and memory. These external events are meant to stimulate cognitive processes occurring within the learner, i.e., the internal condition of learning. Stating the objectives of instruction to the learners stimulates their internal responses (Gagne, 1977, pp. 63-70). Specifically, the expectancies of the learners are influenced by being informed of the objectives, and may have the following effects: helping the learners focus their learning effort, marking progress during practice and feedback, clarifying how learning will be measured, and laying a unifying foundation for the learners.
Stated Advantages of Behavioral Objectives

An often cited advantage of the use of behavioral objectives, when revealed to students, is that they promote learning and hence, better achievement. Arguments in favor of this are as follows:

1. Students have a much better idea of what is expected of them and need not be hindered by the limitations of their teachers (Sheehan, 1974).

2. Students can distinguish between what is relevant and what is irrelevant (Towle and Merrill, 1975; Ausubel, 1960).

3. Objectives help the learner identify the terminal behavior desired by the instructor (Gagne, 1962).

4. Objectives assist students in maintaining their own control of learning task reinforcement (Gagne, 1965).

5. Students feel that they are 'doing' and 'accomplishing' things, and the number of facts learned per learner appears to increase considerably along with the acquired behavior (Kurtz, 1965).

6. The use of objectives facilitates the exploration of alternatives for learning and provide direction for this exploration (Bruner, 1966).

7. Objectives facilitate the learners' organization of knowledge which would direct their thinking to the learning task (Forgus, 1966).
8. Objectives can be made the basis of individualized instruction because they do give the learners goals to achieve, and direction as they process through the instruction (MacDonald-Rose, 1973).

All of these arguments in favor of revealing objectives to students have relevance in terms of preinstructional disclosure of behavioral objectives as an instructional strategy.

A considerable body of research literature on stating behavioral objectives to students before instruction and its effect on cognitive achievement was reviewed by Duchastel and Merrill (1973). They suggested that "objectives sometimes help and are almost never harmful. Therefore, if the provision of objectives is relatively inexpensive one might as well make them available to students" (p. 63). Duchastel and Merrill further suggested that behavioral objectives, as an instructional variable, would seem to fit into the class of variables termed orienting stimuli.

Behavioral objectives help both teachers and students. Once the objectives are clearly stated, the teachers can identify suitable learning experiences and evaluation techniques. The clear statements of behavioral objectives provide a criterion to students against which they can evaluate their own performance. The behavioral objectives are thus useful to both teachers and students in managing instruction and learning. Further, the objectives assist in
planning instruction and facilitating evaluation.

Findings of Related Research

The reported findings of 39 studies which examined the influence of behavioral objectives on student achievement in science were found to be inconsistent and inconclusive. Significant increases in student achievement as a result of the use of behavioral objectives were reported in 14 studies (Dalis, 1970; Edmonson, 1978; Goel, 1980; Hass, 1977; Johnson & Shermen, 1975; Kelly, 1972; Micek, 1974; Miles, 1976; Mosley & Bell, 1976; Muhammad, 1982; Murray, 1985; Olsen, R.C., 1973; Raghubir, 1979; Wingard, 1976), while 25 studies reported no significant treatment effect (Akers, 1979; Baker, 1976; Boardman, 1970; Bryant & Anderson, 1972; Coleman & Fowler, 1973; Conlon, 1970; Dirks, 1980; Forsythe, 1982; Herron, 1971; Hershman, 1971; Jordan, 1971; Kahle, 1978; Koch, 1972; Lynn, 1979; Mottillo, 1973; Olsen, M.D., 1987; Payne, 1972; Pfister, 1981; Rickard, 1985; Schneiderwent, 1970; Shields, 1973; Stedmen, 1970; Treble, 1974; Varano, 1977; Wong, 1980).

A critical review of these studies revealed that a majority were poorly designed. As a result, several of the reported findings are questionable. The inconsistent and inconclusive results of previous research, coupled with the poor research designs used in many of the reviewed studies
reveal a need to conduct additional research using a good design on the influence of behavioral objectives on student achievement.

Six studies investigated the effect of behavioral objectives on achievement in high school (Olsen, M.D., 1987; Payne, 1970) and college chemistry (Boardman, 1970; Herron, 1971; Pfister, 1981; Rickard, 1985). Though the literature revealed the use of behavioral objectives in chemistry, no reported studies could be found which related behavioral objectives to learning effectiveness in laboratory or classroom and laboratory settings. Since the laboratory is an important aspect of science instruction, there is a need to conduct research on the effect of behavioral objectives on student achievement in the chemistry laboratory as well as the classroom, using a good design that should lead to more valid and reliable findings.

**Background of the Problem**

Chulachomklao Royal Military Academy (hereafter referred to as CRMA) is the only army academy in Thailand which offers the Bachelor of Science Degree. No other university in Thailand requires five full years of exhaustive studies in the arts and sciences and 262 semester credit hours to obtain a degree. Only 20 percent of the credits are in military science courses. Every credit hour
represents 16 hours of lectures or 32 hours of laboratory work and at least 14 hours of independent research and study. Excluding military science courses, a CRMA Bachelor of Science Degree requires nearly 70 semester credit hours more than any other degree from any civilian university in the Kingdom.

General chemistry and organic chemistry are required courses for the first and second year cadets. Higher level chemistry courses are offered for the fourth and fifth year cadets. Generally, teachers of general chemistry in CRMA are confronted with problems in two fundamental areas—what chemistry content to teach, and how to teach chemistry. In terms of what to teach, the general chemistry teacher is faced with an expanding number of topics to consider for inclusion in the course. Some topics that were reserved for advanced courses in analytical or physical chemistry are being introduced in general chemistry. The teacher is, therefore, confronted with the problem of trying to select from an expanding body of knowledge those topics which are most appropriate to student needs in subsequent chemistry courses and related fields.

Basically, the primary teaching methods that the general chemistry teachers at CRMA use are lecture, discussion, demonstration and laboratory. All the chemistry teachers are allotted office hours and helping sessions during the time they are not teaching. However, each year
some cadets do not pass the general chemistry course. Because of the large number of science and military training courses in each semester for the first and second year, the independent study time of the cadets is limited. Therefore, the cadets should be provided with alternatives or supplements to the traditional teaching which might guide them to be more successful in the chemistry courses. A variety of tools or methods are available to teachers in an endeavor to increase a student's chance of success in general chemistry. Because behavioral objectives are one of many methods suggested as a means of improving instruction in the classroom, to provide the cadets with behavioral objective might improve their achievement in general chemistry.

Statement of the Problem

The primary purpose of this study was to determine the effects of providing behavioral objectives prior to instruction on the achievement of students in a one-semester college general chemistry course and to determine the effect of providing behavioral objectives of selected chemistry experiments in the acquisition of achievement associated with laboratory work.
Research Hypotheses

The null hypotheses are:

1. There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction.

2. There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction.

3. There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.
4. There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction.

5. There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

6. There is no significant difference in achievement in general chemistry between students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

7. There is no significant difference in classroom achievement in general chemistry between students provided with behavioral objectives and students provided with non-behavioral objectives prior to instruction for classroom
instruction.

8. There is no significant difference in laboratory achievement in general chemistry between students provided with behavioral objectives and students provided with non-behavioral objectives prior to instruction for laboratory instruction.

Assumptions

1. Behavioral objectives play an important role in designing curriculum, planning for teaching and monitoring learning.

2. Advanced organizers can facilitate learning.

3. The effects of providing behavioral objectives to the students prior to instruction on student achievement in science are inconclusive and contradictory.

Limitations

1. This study was limited to students at CRMA who enrolled as first year cadets in general chemistry.

2. The behavioral objectives used in this study were limited to the cognitive domain (Bloom, 1956).
Delimitation

No attempt was made to evaluate the effectiveness of chemistry instruction.

Definition of Terms

The following definitions were used in this study:

**Achievement** is the composite test score of classroom and laboratory achievement tests obtained from a teacher-made achievement test conducted to measure the established behavioral objective for both classroom and laboratory instruction.

**Classroom achievement** is the test score a student obtains from a teacher-made achievement test constructed to measure the established behavioral objective for classroom instruction.

**Laboratory achievement** is the test score a student obtains from a teacher-made achievement test constructed to measure the established behavioral objectives for laboratory instruction.

**Classroom instruction** refers to a process of instruction in which the teaching methodology is emphasized on lecture, group discussion, and demonstration.

**Laboratory instruction** refers to a process of instruction in which the teaching methodology is emphasized
Behavioral objectives are specific instructional objectives which describe an intended outcome of instruction and describe to the learner the type of terminal behavior expected. The terminal behavior includes:

1. identifying and naming the observable act that will be accepted as evidence that the learner has achieved the objective;

2. describing the important conditions under which the behavior is to occur; and

3. defining the level of performance necessary to prove that the objective was met (Mager, 1962).

**Example of behavioral objective**

Given the chemical formula, a periodic chart, and a hand calculator, calculate the formula weight of a compound correctly to three significances.

**Non-behavioral objectives** are statements of behaviors couched in vague or general terms without exact specification of performances. Typically the student is told to "know" or "understand".

**Example of non-behavioral objective**

The student should understand that chemical reactions occur when the atoms in substances rearrange and combine to form new substances.

**Control group** refers to students who are given non-behavioral objectives.
Experimental group refers to students who are given behavioral objectives.

Methodology

The population of the study is composed of 244 students (12 class sections) taking first-year chemistry. There will be random assignment of intact classes to four different treatment groups. Previous semester final exam scores serve as pretest scores and students will be given posttests at the end of the study period in chemistry. Scores from pretests serve as the covariate. The statistical methods for analyzing the data consist of two techniques: A one-way analysis of covariance and Scheffe's test for multiple comparisons for evaluating the differences between various pairs of treatment achievement test scores.

Outline of the Remainder of the Thesis

Chapter II presents the related literature. Chapter III presents the methodology of the study. The analysis and interpretation of the findings are reported in Chapter IV. Summary, conclusions and recommendations are presented in Chapter V.
CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this chapter is to review research reports in which the influence of behavioral objectives on student achievement in science was examined. They include thirty-nine research reports.

Based on the area of science, this chapter is organized into six sections. The first section includes thirteen reports in biology. The second section contains six reports in chemistry. The third section includes five reports in physical science. The fourth section contains five reports in physics. The fifth section includes four reports in general sciences. The sixth section consists of six reports in other science studies.

A summary based on reviewed research reports are provided in the seventh section.

Biology

Stedman (1970) determined the effectiveness of providing students with behavioral objectives (hereafter referred to as BOs) prior to a learning task. On the basis of scores on the mental ability test and a motivation scale, 144 subjects were assigned to one of six blocks. Subjects were then assigned randomly to one of four treatments. This procedure yielded 24 cells, each containing six subjects.

A list of 23 BOs was prepared as a guide for the development of the program and to serve as a guide for subjects in the treatment groups using the programmed materials. These objectives consisted of three distinct parts: a statement of the situation, a performance term, and a qualifying term.

The appropriate programmed materials were administered to each of four groups. Group one, the control, received programmed genetic materials without any statements of objectives. Group two received the programmed materials with non-behaviorally stated objectives. Group three received a statement of the situation and a performance term. Group four received these two terms plus a qualifying term. Subjects were all treated in the same manner. All worked on the programs during the regularly scheduled class periods, and the programs were collected at the completion of each class period. All subjects completed the program within seven class periods. Subjects were given a posttest upon completion of the program.
A factorial analysis of variance was used to analyze the four subscores recorded for knowledge, comprehension, application, and analysis. The reported results were as follows.

1. The specific forms of objectives inserted into programmed materials in genetics had no significant effect on cognitive achievement.

2. Mental ability and motivation significantly affected achievement beyond the .01 level.

3. The four levels of achievement were significantly different beyond the .001 level. Scheffe's Test indicated that significant differences existed between knowledge and application, knowledge and analysis, comprehension and application, and comprehension and analysis. The researcher stated that significant differences found between comprehension and application when no differences were noted between knowledge and comprehension or application and analysis leads to the inference that these levels may not be equitable in the cognitive processes involved at each level.

Stedman concluded that providing students with a form of behaviorally stated objectives prior to their learning experience with programmed materials did not positively influence achievement.

Jordan (1971) used a non-equivalent control group design to investigate the effect of the use of behaviorally stated educational objectives on the understanding of
science, and the attitude toward biology of students taught by three different methods of instruction in introductory college biology. Three intact college classes of Biology 101 were involved with 25 students in experimental group I, 28 in experimental group II, and 22 in comparison group III. Two groups of students (I and II) were taught by a student-centered, laboratory-project methodology. The science section of Sequential Tests of Educational Progress (STEP) was used as both pretest and posttest to determine the level of understanding of science by the students in three groups.

A pretest was given to all students at the beginning of the course. Group I was given BOs along with an orientation to the purpose of such objectives, experienced student-centered teaching, and were informed that they would be tested to determine the degree to which they had attained the objectives and graded accordingly. Group II received student centered teaching as did Group I, but was given no BOs. Group III received neither behavioral objectives nor student-centered teaching. At the end of study, all students were given a posttest to determine their level of science understanding. Along with the science posttest, all students completed an attitude instrument designed to measure students' attitude toward the college biology course. The analysis of variance on posttest STEP science scores revealed no significant difference in understanding of science between the three groups of students. The group of
students receiving student-centered instruction utilizing BOs showed a positive attitude (+0.71) toward Biology 101 that was significantly different from the attitude shown by the students receiving student-centered instruction with no behavioral objectives (-0.56), and to the attitude shown by students receiving group-oriented traditional instruction (-0.09). There was a significant interdependence between understanding of science and attitude toward biology; i.e., students' level of understanding of science was dependent upon their attitude toward biology and vice versa. Jordan concluded that the method of instruction in biology effected little difference in the level of understanding of science measured by STEP science scores. The use of BOs was the best method of instruction for developing a positive attitude toward biology.

Kelley (1972) investigated the relationship between the use of stated instructional objectives and achievement in audio-tutorial instruction (A-T) and the relationship between learner personality and achievement under conditions of A-T. An intact college class (288 subjects) taking biology 206 was randomly assigned to one of three treatment groups: (a) a group which received objectives specified behaviorally (n=92), (b) a group which received parallel, but non-behavioral objectives (n=97), and (c) a group which received no objectives (n=99) for each of six A-T units in genetics.
Instructional objectives, audio scripts, visuals, study guides, and criterion measures were jointly developed by the senior professor, the graduate instructor and researcher. Reliabilities were established for each criterion measure by the test-retest method. The correlation coefficients for six quizzes and the hour-long examination ranged from 0.64 to 0.84.

During a six week period, subjects whose treatment consisted of exposure to objectives, specified in either behavioral or non-behavioral form, received not only a printed version in the study guide, but also listened to a recorded version on audio tapes. Both audio and visual materials for subjects in group III contained no stated objectives. The weekly quizzes were administered during the lecture periods. A one-hour examination was administered at the end of the study.

The first analyses performed were between group analyses of variance on the achievement of the three treatment groups on each of seven criterion measures. For this stage of the analysis, no significant F-ratios were found. Analysis of variance for between and within group differences on repeated measures indicated significant differences at the 0.95 confidence level. The Newman-Keuls Sequential Range Test indicated a significant difference in the average criterion measure score between the means of treatment I and III, in favor of group I. Kelly concluded
that the differences between treatment groups would probably have been greater had the experimental setting been different. In the present study, the experimental groups were exposed to the stated objectives intended for them by both audio and visual means to insure their awareness of the objectives. Furthermore, these treatment groups were exposed to such objectives in an isolated learning environment of the individual A-T carrel, and only on a lesson by lesson basis, as needed for proceeding through each unit of the total instructional sequence.

Shields (1973) studied the effects of BOs on achievement in a biology class which utilized a self-instructional, multi-media approach known as the audio-tutorial approach. The sample population consisted of 174 students enrolled in three sections of Biological Science 107. The treatment was randomly assigned to these pre-assembled class sections. The BOs for each unit were written according to the style proposed by Gronlund (1970). The BOs were developed by the investigator from examinations of the tape presentations, interviews with the instructors, review of the principles in the textbook, and examination of BOs in current literature. The teacher-made achievement test items were constructed from using content specified in the tape presentation, textbook, laboratory demonstrations, and questions on past unit tests. Test items were selected to closely correspond but not be identical to the BOs. The
tests were validated by the panel of judges. Cronbach's modification of the Kuder-Richardson formula 21 was use to obtain reliabilities for the unit tests (r=0.10 to 0.74).

Treatment for the experimental group I (n=66) involved providing students with prior knowledge of BOs before instruction for each of the thirteen units. Treatment of experimental group II (n=50) also involved providing the students with prior knowledge of BOs before instruction. However, the interval of exposure to BOs use involved only the last six units (8-13) as opposed to all 13 units. The control group (n=58) did not receive any objectives or placebos.

No significant differences were detected which would indicate that those classes provided with BOs prior to instruction achieved higher mean scores as measured by unit tests and posttest than for those classes not provided with the BOs. Significant sex and ability level differences were not found. The researcher concluded that the results of the study did not support the use of BOs as a procedure for enhancing achievement in an audio-tutorial biology class.

Micek (1974) used a simple posttest-only 2x2 factorial design to conduct a study concerned with two aspects of the use of BOs in instruction i.e, the effect of training students in the purpose and use of BOs on their achievement and learning time expenditure, as well as the effect of allowing students to participate in selection of BOs to be
mastered on their achievement and learning time.

Thirty-two students were assigned randomly to four experimental groups. Group A received training in the use of BOs and participated with the instructor in the selection of the objectives to be mastered. Group B received only training in the use of BOs. Group C was not given any training in the use of BOs, but did participate in the selection of the objectives for each unit. Group D did not receive training in the use of objectives, nor were they allowed to participate in the selection of unit objectives to be mastered.

Test items in each criterion exam were constructed to correspond to the BOs selected for mastery in each of the instructional units. The researcher reported that content validity for the items in the criterion exams was achieved by having a panel of biology instructors from a Community College review the substance and appropriateness of each test item. An overall reliability coefficient for the three instructional unit criterion exams was estimated using the split-half reliability method. A Pearson product-moment correlation coefficient of 0.82 was obtained.

An analysis of variance for a randomized groups 2x2 factorial design was used to analyze the data for each instruction unit. Training students in the purpose and use of BOs prior to the start of the course had a significant effect on the number of objectives mastered in the initial
unit of instruction. Based on this finding, it was concluded that such training prior to the start of a course may help students better understand what they need to do to successfully master the BOs for the course. Training was found to have no significant influence on the amount of student learning time expended toward achieving the instructional unit's objectives. Allowing students to participate in selecting the BOs to be mastered in each of the three instructional units was found to have no positive influence on the number of objectives mastered. The researcher reported that a significant negative effect was found, which indicated that students may have viewed their participation as an inappropriate and illegitimate activity. Participation was found to have no significant impact on the amount of student learning time expended toward achieving the instructional units objectives.

Treble (1974) studied whether teaching anatomy laboratory classes in an innovative manner using BOs would result in more effective learning and retention than classes taught in a traditional manner, without the use of BOs. It was also intended to determine if the students in the classes being taught using BOs acquired better anatomical concepts.

A total of 74 college students served as the subjects for this study. Thirty seven of these students formed three classes which were taught anatomy laboratory without BOs.
The remaining thirty-seven students formed four classes which were taught anatomy laboratory with the addition of BOs.

Laboratory examinations, which included 40 questions and required a knowledge and understanding of anatomical features which were identifiable on either charts, models, or cadavers. The instrument was validated by two other laboratory instructors and the professor who directed the anatomy and kinesiology studies. Reliability was 0.90 (split-half). The professor in charge of the anatomy course who also taught the anatomy theory classes, designed questions for the regular midterm examination that would evaluate the student’s ability to develop anatomy concepts.

There were no significant differences in learning between the two groups, taught by two different methods of anatomy laboratory. A significant difference was revealed when the two groups' anatomical concepts were measured and then compared. The difference favored the experimental groups at the 0.05 level. The researcher reported that it might be plausible to consider that those students not receiving instruction with BOs in the laboratory were less able to comprehend discussions in the theoretical classroom setting. When the retention of anatomical knowledge of two groups was compared after a retention period of two weeks, no significant difference was revealed. When the retention period was extended to four weeks, a difference in
retention, significant at the 0.01 level of confidence, was found. The difference again favored the group which was taught innovatively with BOs. The researcher concluded that, while BOs do not seem to influence retention over a short period of time, they do seem to enhance the retention of anatomy laboratory knowledge over an extended period of time.

Hass (1977) conducted a study to determine the effects of the use of performance objectives on achievement in biology, and attitudes toward the class, of two classes of non-science majors enrolled in biological science. One class of 111 students served as a control section, and a second class of 64 students was used as a treatment section. Fourteen lists of performance objectives were developed by the researcher from the content of three teacher-constructed tests. Each list of objectives was submitted to the doctoral committee for criticisms, refinement, and approval.

Scores on the ACT Natural Science Reading Test were used as a measure of scientific development and ability of each subject, and also to group the subjects into high, middle, and low ability level. This test consists of fifty-two items. The researcher reported that validation for the Natural Science Reading Test had been extensive, and its reliability coefficient was reported as 0.91. The reported reliability of the Nelson Biology Test ranged from 0.89 to 0.92 for four schools involved in the standardized study.
Students in the experimental group received the objectives for each chapter at least two days prior to the classroom treatment. Both classes met three times per week for eleven weeks. The first teacher-constructed test was administered after the third week of instruction, the second test after the seventh week, and the third test after the tenth week. The Nelson Biology Test was administered during the last class meeting of the quarter. Both of the attitudes scales were administered during the last week of class for the quarter.

Analysis of covariance with ACT Natural Science Reading scores as the covariate was used in adjusting the mean scores of achievement of the two groups. In testing for significant differences between the two groups in regard to attitude toward instruction and attitude toward the course, analysis of variance was employed. Two way analysis of variance, with two levels of treatment and three levels of ability, was used in testing for interaction between the main effects of treatment and ability level on the dependent variables of achievement on Nelson Biology Test and attitudinal instruments. The Pearson product moment correlation coefficient was utilized in determining the degree of relationship between achievement and both attitudinal scores for each group.

The researcher reported that the treatment group subjects scored significantly higher than the control group
subjects on the composite total of teacher-constructed tests. All other comparisons indicated no statistically significant differences between the two groups.

Varano (1977) determined the effects of an advance organizer, BOs, a combination of advanced organizer and BOs or a historical passage on the facilitation of learning and retention of a tenth-grade biology unit when the entering behaviors were considered. Four classes of BSCS Yellow Version Biology consisting of 103 students participated in the investigation.

A prior knowledge pretest (PKT) consisting of 35-item multiple choice questions was developed by the investigator by selecting the items from A Resource Book of Test Items for Biological Science -- An Inquiry Into Life (BSCS, 1968, 1971) and A resource Book of Test Items for BSCS Green Version High School Biology (BSCS, 1971). Kuder-Richardson formula estimated reliability was 0.80. A posttest consisting of 35-item multiple choice questions was selected from the same material. Test reliability for the posttest using the Kuder-Richardson formula 20 was 0.86.

One week prior to receiving the instructional treatment a PKT was administrated to each student during his regular class period to determine his familiarity with the new instructional material. After being tested for prior knowledge, the I.Q. scores from seventh-grade test using the California Test of Mental Maturity were obtained. Scores
from these two tests were used to partition the students into high and low groups to analyze for any interaction between the treatments and the entering behaviors.

The experimental data collected from the 103 tenth-grade biology students were analyzed for significant differences between the mean scores of the four treatments and also for interaction between the entering behaviors, prior knowledge and mental ability, using an analysis of variance technique. Results of analysis revealed no significant differences at the 0.05 level of confidence between the four instructional treatments on immediate learning or long-term retention. The researcher concluded that the results obtained in this study indicated that learning was enhanced for those students receiving the advance organizer treatment even though the differences in mean scores were not significant.

Kahle (1978) conducted a study to determine the effects of advanced organizers and BOs on meaningful learning by disadvantaged students. All 105 subjects were enrolled in an introductory biology course taught by two experienced biology teachers.

During the course of the six week experimental period, all subjects received audio tapes, study guides, visual aids, and tests. The control group received historical reviews for each topic, while the experimental group received advanced organizers or BOs or both. For each of
three units, the historical review and the treatment materials were approximately equal in length and in difficulty. The reviews and treatments material were presented by audio tape as well as by printed format.

After finishing each unit, the students completed a 25 items multiple choice and following completion of three learning units, all students took the 30 items summative final. The researcher reported that all tests were validated by science educators. A split-half reliability coefficient was calculated for the unit tests (r=.64 to .80) and for the summative final (r=.69). In addition, learning retention was assessed by retesting the subjects with the summative final three weeks after the experimental period.

T-tests were used to compare the mean scores of the experimental and control groups on each of the unit summative final and retention tests. The results indicated a significant difference in achievement in favor of the treatment group where an advanced organizer was utilized in the meiosis unit and when both an organizer and BOs were introduced prior to the chromosome abnormalities unit. However, the use of BOs alone did not produce a significant difference in learning. Although no significant difference was found between the two groups when t-tests were used to compare the means of the summative final test, the experimental group achieved significantly better on the retention test.
Raghubir (1979) conducted a study to determine the results of the use of learning outcomes on achievement and retention in science teaching. The sample population consisted of 62 students enrolled in a Grade 11 biology course. The experimental and control groups, 18 and 20 students respectively, were selected from this sample. The researcher reported that the two groups were adequately matched using the Canadian Lorge Thorndike Intelligence Test and the STEP test.

Achievement and retention tests were prepared from BSCS Blue Version, Quarterly Achievement Tests and Comprehensive Final Examinations. The reliability estimates using Kuder-Richardson formula 21 ranged from 0.78 to 0.84.

Students in the experimental group were given the list of learning outcomes prior to each instructional unit one at a time. These were referred to as the teacher interacted with the students. The same learning outcomes were withheld from the control group and were at no time referred to for the duration of the study. Both groups were taught by the same instructor. At the completion of each unit with about 15 to 18 learning outcomes statements consisting of 12-45 minute periods, both groups took the same achievement test, multiple choice test and retention tests based on learning outcomes.

Mean scores from both groups were analyzed using the paired t-test. The experimental group obtained higher mean
scores than the control group on both achievement and retention tests which incorporated learning outcomes higher than the knowledge level. Mean scores were not reported. The researcher concluded that students receiving instruction with a prior knowledge of learning outcomes did achieve significantly higher on immediate and delayed posttests as measures of performance.

Forsythe (1982) conducted a study to investigate the efficacy of advance organizers and BOs, when provided simultaneously, on the achievement of community college students. The advance organizers, BOs, and biographies of famous scientists, which were used as a placebo, were written by the investigator and constituted the treatments. The treatments were distributed in varying sequences prior to instruction to 144 students. The students, who were divided into four sections and were told to use the organizers and/or objectives to prepare for the lectures and examinations.

All data collected subsequent to the first examination were analyzed by covariant analysis with the results of the first examination serving as the covariant. Following the covariant analysis of the second examination, significant variance in achievement was observed between the section which was provided with the combined treatment and those sections given the singular use of the same learning cues, but no significant variance was observed between the
combined treatment section and the control section during the same treatment period. Following the covariant analysis of the third examination, significant variance in achievement was observed between the section provided the combined treatment and the control section, but no significant variance was observed between the combined treatment section and section given behavioral objectives only. No significant variance was observed between any sections for any treatment following the examinations subsequent to the third examination. The researcher concluded that the efficacy of advance organizers and behavioral objectives when used as a combined treatment with science related material can not be determined with assurance.

Muhammad (1982) investigated the effects of specific behavioral objectives versus study questions on learning of undergraduate biology students. Eighty-two subjects were randomly assigned to four groups. Group A consisted of 21 subjects who were given specific behavioral objectives and study questions, Group B consisted of 21 subjects who were given study questions alone, Group C consisted of 20 subjects who were given specific behavioral objectives alone, and Group D consisted of 20 subjects who were given neither specific behavioral objectives nor study questions. The investigator served as instructor for these groups.

One-way analysis of variance was employed to test for
group differences in pretest scores, general achievement, and biology aptitude. The covariance analysis of posttest scores indicated significant differences among group means. Pairwise comparisons by means of Fisher's LSD revealed that Group A scores were significantly higher than Group C and Group D but not Group B. Additionally, Group B scored significantly higher than Group C and Group D. Group D and Group C did not significantly differ. The same analysis of retention test scores revealed significant differences among group means. Group A retained significantly more than Group C but did not retain significantly more than Group B or Group D. Group B retained significantly more than Group C and Group D. Group C and Group D, however, did not significantly differ. The researcher reported that the results indicated that subjects who had study questions included in the preinstructional activities learned more and retained more information, than subjects who had no study questions. No support was found for the use of specific behavioral objectives as preinstructional strategy.

Murray (1985) used a posttest only control group design to determine the effect of prior knowledge of BOs at the knowledge and comprehension levels on relevant and incidental learning. The subjects were 97 tenth grade students enrolled in introductory biology. Six class sections were involved. One-third of the students in each of the classes was randomly assigned to each of the three
levels of the behavioral objectives treatment variable. Under condition one (A1), students were given no prior knowledge of BOs. Condition two (A2) consisted of providing students with written copies of the BOs prior to instruction. The third condition (A3) included providing students with copies of BOs prior to instruction, open group discussion of the BOs, students paraphrasing of objectives, and teacher feedback as to the accurateness of the paraphrasing. The equivalency of the groups was established using scores from the California Achievement Test.

Two-way analysis of variance (sex and treatment) was used to analyze the data. The following findings were reported: (1) students given the objectives alone and those given the objectives along with discussion, paraphrasing and feedback performed significantly higher on relevant knowledge and total relevant learning than students not given objectives at the 0.05 level; (2) no significant differences were noted on these measures between students given the objectives alone and students given the objectives along with discussion, paraphrasing and feedback; (3) there were no significant differences between the three groups in relevant comprehension or any phase of incidental learning; (4) girls scored significantly better than boys on relevant knowledge at the 0.05 level, and (5) there was a greater discrepancy between relevant knowledge and incidental knowledge for students given the objectives alone and
students given the objectives along with discussion, paraphrasing and feedback than for students not given the objectives at the 0.05 level.

Chemistry

Six studies investigating the effects of BOs on student achievement in chemistry were identified. These included Boardman (1970), Herron (1971), Payne (1972), Pfister (1981), Rickard (1985), and Olsen (1987).

Boardman (1970) used a posttest only control group design to test whether an advance knowledge of BOs would enhance students' learning. One-hundred and forty-one students in three remedial chemistry classes in a junior college were selected. They were randomly divided into groups which received different treatments. Group A received packets containing BOs relating to the unit under study and attended lecture and laboratory (n=38). Group B received packets containing BOs but did not attend lecture and laboratory (n=37). Group C received packets containing a paragraph on a chemical topic unrelated to the material under study (a placebo) and attended lecture and laboratory (n=31). Group D received packets containing a placebo but did not attend lecture and laboratory (n=35). Twenty-six BOs were prepared and duplicated for distribution. The BOs were classified as knowledge, comprehension, application, and
analysis using Bloom's Taxonomy (1956). After each objective, two questions were asked. Some of the questions covered the material included in the objective and some did not. The student was asked to indicate if one question covered the particular objective, if they both covered the particular objective, or if neither covered the particular objective. Twenty-six placebos were prepared and duplicated for distribution. These were paragraphs concerning chemistry, but not related to the units covered in the investigation.

A multiple-choice examination containing 27 questions was developed. Each question was constructed by the investigator. Packets were given to each student during the meeting of the lecture section. It was explained to the students that they were being asked to participate in a learning experiment, and their cooperation was solicited. Placebos and B0s were collected at various periods, and the responses to the objectives were tabulated. At the end of the three week periods, all students were given the test. A student questionnaire on the value of the packets was included with the examination.

An analysis of variance showed no significant difference in achievement among students who received B0s, whether they attended lecture and laboratory, or whether they did not. Also, there was no significant difference in achievement of students who received a placebo, whether or
not they attended lecture and laboratory. And there was no significant difference between the groups with BOs and those without. No significant difference in performance was observed whether or not the students with objectives understood them, as long as they attended lecture and laboratory. However, a correlation analysis showed that the group which did not attend lecture and laboratory, performance was definitely related to the students' understanding of the objectives (correlation coefficient, Group A=-0.08, Group B=0.49). Results of a questionnaire indicated that more students who had the packets which contained the behavioral objectives considered the packets helpful, than those who received the packet containing placebos.

Herron (1971) conducted a study to determine whether or not students in a large introductory college chemistry course would improve their achievement on the course examinations when given lists of objectives which described what they were expected to learn. The sample population was drawn from 650 students enrolled in a freshman chemistry course for science and engineering majors. Sixteen class sections (24 students each) were selected, and all students in a section were assigned as a block, to either a treatment or a control group. Students were divided into three ability levels of approximately equal size using SAT, and diagnostic test scores. The treatment consisted of handing out lists of
performance objectives to students in experimental groups during the recitation class. Students were told that the lists should help them understand what was expected of them in the course, but no other instructions were given.

The criterion test consisted of three one-hour examinations prepared by the lecturer in the course. No effort was made to make the examinations correspond exactly to the objectives lists. Kuder-Richardson formula-20 estimates of reliability for the three examinations ranged from 0.68 to 0.72.

Analysis of covariance (SAT scores as covariate) showed that there were no significant differences in means for the first exam and third exam. A significant difference due to treatment was found for the second exam. A difference in means for the lower third of the class favored the experimental group and was significant at the 0.05 level. A difference in means for the upper third of the class also favored the experimental group and was significant at the 0.1 level. A separate analysis of covariance was done using scores on a diagnostic test as the covariate. Only on the second exam was there a significant difference in means for the upper third of the class, which favored the experimental group and was significant at the 0.05 level. The researcher reported that the data for the second exam suggested that in a large course, in which students may have difficulty in understanding exactly what was expected, the simple
procedure of providing a list of BOs would help them to learn the required material. No consistent correlation was found between the use of BOs and students ability and performance.

The limitations associated with this investigation were identified. First, the teaching assistants in charge of the control group were not aware of the objectives; therefore, the increased student performance could be the result of treatment group teaching assistants covering the correct or incorrect material. The differences observed may have been the result of indirect benefits resulting from the GTA having lists of course objectives rather than direct benefits of students having lists of course objectives. Secondly, no data were obtained as to whether the students actually used the objectives. Thirdly, there may have been contamination of the control group by information received from the treatment group.

Payne (1972) used a pretest-posttest experimental design to investigate the possible effect that the use of BOs would have on the achievement of high school chemistry students. It was determined also if BOs work best for a particular I.Q. level. Seven high school chemistry teachers and their respective classes participated in this study. The seven teachers were not randomly selected and participated on a voluntary basis. They were randomly assigned to either the control or the experimental groups.
The experimental group consisted of four teachers and 140 students, while the control group consisted of three teachers and 119 students. Students in each group were divided into three ability levels using I.Q. test scores.

A pretest of the investigated chapters was given to all participating students. Immediately after each chapter had been covered, the same test was used to test for achievement as a result of using BOs.

The data were subjected to a one-way analysis of variance. It was reported that in the analyses of gain scores for the two chapters, that the F-ratio was approaching significance in favor of the experimental group. Interaction analysis revealed that the F-ratios were approaching significance in favor of the experimental group. The researcher reported that the results of this study did not provide adequate evidence that students achieve more when using behavioral objectives. The results of the questionnaires indicated that teacher and student attitudes vary somewhat, but there was an overall favorable attitude toward the use of behavioral objectives.

Pfister (1981) conducted a study to determine the effect of providing and using BOs on the achievement of students in a one-semester college general chemistry course. In addition, the effect of providing and using BOs with respect to academic development levels, as measured by American College Testing (ACT) composite scores, and locus
of control levels, as measured by the Rotter (1966) Locus of Control Scale was considered.

The subjects included 61 students enrolled in three sections of general chemistry (n=31, 20 and 10). The two smaller sections were nested within one group in order to attain approximately equal numbers of students who received the treatment, and who did not receive the treatment. The two groups were randomly assigned to receive either the BOs treatment or no treatment. The students in each section were randomly assigned to receive either the pretest or posttest for each unit.

The BOs used in this study were developed according to the criteria of Mager (1962) from selected performance objectives provided in the solutions manual which accompanied the text. Multiple choice tests were constructed for each of the two units. One multiple choice question was constructed for each behavioral objective. A group of three community college chemistry teachers verified the appropriateness of the BOs and the corresponding multiple choice test questions for each of the two units. The reliability estimates of the two tests based on the Kuder-Richardson formula 20 were 0.78 and 0.73, respectively.

Students in the treatment group received written BOs at the beginning of each chapter during two four-week units of study. The treatment group also received instruction on the meaning and use of BOs. The objectives were reviewed during
the closing remarks of each lecture period with the aid of overhead transparencies.

Data were analyzed separately for each unit and for each blocking variable, using a multivariance analysis. There was no significant difference in achievement between the students who received and used BOs and those who received no objectives. The results of the questionnaires revealed that students in the treatment group considered the objectives to be beneficial. Most of students used the objectives to study for the unit tests and felt the objectives helped them decide what to study for the tests.

Rickard (1985) used a non-equivalent control group design to determine the effect of BOs or a BO in conjunction with instructional objectives on the performance of a college general chemistry class. Of particular interest was whether the use of BOs was detrimental to understanding of science and science concepts, and whether the use of BOs in conjunction with instructional objectives would overcome this criticism of BOs in the physical sciences.

The sample consisted of 457 students in a college level general chemistry course. The experiment was performed using four existing chemistry 101 classes. Two classes were assigned to the treatment group, one receiving only behavioral objectives (n=73) and the other receiving behavioral objectives in conjunction with instructional objectives (n=147). The remaining two classes were assigned
to the control group (n=95, 142). Two instructors were involved in this study. Each instructor was given an experimental and control group.

The student achievement test (part I) was made up of twenty multiple choice items. Each item was based directly on one of the BOs received by the treatment groups. A split-half reliability coefficient corrected with Spearman-Brown formula was reported as 0.75. An understanding of science test (part II) consisted of 20 multiple choice items selected from the Test of Understanding Science (TOUS) by L.E. Klopfer. A Split-half reliability coefficient corrected with the Spearman-Brown formula was reported as 0.65. An understanding of chemical concept test attempted to measure whether or not students understood the concepts described in the instructional objectives. Each item was based on one of the instructional objectives. Reliability, based on the Spearman-Brown formula, was reported as 0.74. The pretest was administered to all four groups at the beginning of the semester. A set of objectives was distributed with unit assignments at the beginning of each of the four units. All four groups received the unit assignment, but only the experimental groups received the objectives. The students were encouraged by the instructors to use the objectives in their course preparation. Students were informed that the objectives would be particularly helpful in deciding what material was important to understand for the exams. Data
concerning the extent of use of the objectives were gathered on the posttest by asking students to write either extensively, some, or none on their test papers. Students in experimental groups were subsequently classified into one of the three categories.

Analysis of covariance was performed on the three dependent variables using the pretest as the covariate. No significant differences were found between groups. The researcher reported that this would indicate that the use of behavioral objectives was not detrimental to understanding science or chemical concepts. However, the study's results also indicated that neither behavioral objectives nor behavioral objectives in conjunction with instructional objectives, increase student achievement, understanding of science, or understanding of chemical concepts.

Olsen, M. D. (1987) used a posttest only control group design to determine the effects of various presentations of objectives on learning a set of four acid-base chemistry lessons presented on a microcomputer interactive videodisc (MCIV) system. Focusing on the possibilities of how objectives could be presented to the learner the researcher analyzed and compared the achievement of 132 high school chemistry students receiving MCIV instruction. These students were randomly assigned into three groups as follows: (a) those presented with lesson objectives, identified as objectives, through text (n=48); (b) those
presented with objectives through text and visualization (n=41), or (c) those who heard only the goals, stated on an audio track, but not identified as objectives (n=43).

Four to six weeks before the study began, a pretest was administered by the chemistry teachers. The three treatments were contained on separate lesson diskettes. Students in the two groups with objectives were first shown a screen which briefly explained what objectives were. Those in the "text only" group were shown the objectives for a lesson, one at a time, by computer text. Those in the "text plus visualization" group were also shown each objective, but they were then shown a visualization of it, such as a still frame, a graph, a formula, or a video sequence. Those in the "goals only" group heard only a general statement of the goals of the lesson. After completing the lessons, the students' learning of verbal information and intellectual skills was assessed by an objectives-referenced posttest.

An analysis of covariance, with the pretest as the covariate, revealed no significant differences among the groups with respect to achievement. The researcher reported that the lack of significant results might have been because of the effects of such an instructional novelty, or because of the structured materials being used.
Physical Science

Five investigations were reviewed in which the effects of BOs on achievement in physical science was examined. These included Coleman and Fowler (1973), Olsen (1973), Mosley and Bell (1976), Akers (1979), Dirks (1980).

Coleman and Fowler (1973) used a pretest-posttest control group design to investigate differences in learning as attributed to the instructional treatment of behavioral objectives of students enrolled in a general physical science laboratory.

The subjects used in this study were 94 freshmen who enrolled in the Thirteen College Curriculum Program (TCCP) Physical Science Course. The students were divided into two group by selecting a laboratory number. Five test instruments were used in this study. These included School and College Ability Test (SCAT), Welch Science Process Inventory (WSPI) Form D (1966), Sequential Test of Educational Progress (STEP) Form 1B (1957), teacher-made achievement test, and Watson-Glaser Critical Thinking Appraisal (1961). Following the pretest, students in the experimental group received BOs, and the control group received placebos.

The data were analyzed using analysis of covariance (SCAT and WSPI as covariates). There was no significant difference between presenting performance objectives and not
furnishing performance objectives to the students. No significant difference in achievement was evident between the experimental and control groups with respect to sex of the subjects. Nor was there a significant difference in terms of attitudes toward sciences as it was related to sex of students when attitudes are controlled by an analysis of covariance.

Olsen, R.C. (1973) used a pretest-posttest control group design to assess the effects of BOs on class achievement and retention. The 306 students in 14 ninth grade physical science classes from two junior high schools served as subjects. Intact classes were randomly assigned to eight experimental and six control classes.

Eighteen objectives and 36 assessment tasks were constructed by the researcher and evaluated by ten educators. The sequential Test of Educational Progress (STEP) was used as a pretest. The researcher stated that the STEP test was a 50-item, multiple choice test with a reported reliability coefficient of 0.89. The Interaction of Matter and Energy (IME) quarterly and final achievement tests were designed by Rand McNally & Company. Each of them were 50-item, multiple choice examinations reporting reliability coefficients ranging from 0.832 to 0.867.

Two weeks following the administration of the STEP test, the instructional program began in all classes. The experimental classes were given the BOs for each chapter,
one chapter at a time. Following this initial overview of the chapter's objectives, assessment tasks were provided, one objective at a time, to insure a more complete exposure and reinforcement for each of the B0s. At the conclusion of the three month instructional period, the IME achievement test was administered to all 14 class sections. After three weeks, the retention test was administered.

The analysis of covariance tested the effect of treatment on achievement and retention for experimental and control classes. The experimental group obtained significantly higher mean scores than the control group on both achievement and retention tests at the 0.01 level.

Mosley and Bell (1976) used a non-randomized control group pretest-posttest design to examine the influence of objective statement specificity on student learning resulting from an independent laboratory-based Physical Science Investigations program. One-hundred and thirty-eight eighth grade students from six intact classes participated in the study. Test items were agreed upon by participating teachers. Test items included multiple choice, fill-in and problem-solving questions; all items were given equal scoring weight. The odd/even split reliability coefficient was 0.73.

Each teacher taught one section using specific behavioral objectives and one section of non-specific objectives. In both treatments, objective statements were
presented to the students prior to the instruction of the unit.

Pretest scores showed no significant difference between classes. The posttest data were analyzed using a two-way analysis of variance. A significant difference was found between mean scores of the treatment group. Any difference that occurred in the pretest would have been taken into consideration.

Akers (1979) used a non equivalent control group design to determine to what extent student achievement was affected when BOs developed by the investigator for a portion of a widely used inquiry-oriented science curricular program were either presented, or not presented, to students prior to instruction.

The subjects participating in this study were 424 eight grade students enrolled in Introductory Physical Science (IPS) in three junior high schools. Classes for each of six teachers were randomly assigned to treatment, mixed, or control groups (18 classes).

Achievement was measured using the Short Test of Education Ability (STEA), SRA Science Aptitude Test, and competency measures of ten items selected from IPS achievement test using BOs for each of four units. The behavioral objectives, pretests and competency measures were reviewed by a validation panel for content agreement with the IPS program. A Kuder-Richardson formula 20
reliability estimate was calculated for the pretest (r=0.008) and the four competency measures (r=0.530 to 0.587).

The treatment classes received BOs for all four instruction units, the mixed classes received the objectives for alternate units, and the control classes did not receive objectives. The students in the treatment group were provided with the BOs on the first day the unit of study was presented. They also received information concerning the nature and use of the objectives, and were informed that the objectives were to be used as study guides and contained important concepts that their teacher hoped that they would master for that portion of the course. Analysis of pretest data showed no statistical differences between groups prior to the implementation of treatment. From repeated measured analysis of variance it was found the BOs treatments did not produce overall statistical significance for the four instructional units. Examination of overall mean scores on the competency measures revealed that students who received objectives had scores slightly higher than those who did not, and males had a slight edge over females. Regression analysis was used to determine whether achievement differences existed for each instructional unit. A significant F ratio was produced with the third instructional unit in favor of the group that received behavioral objectives. Student ability and science aptitude
were both highly correlated with competency measures scores.

Dirks (1980) determined whether different learning levels of behavioral objectives and the times of their possession enhanced relevant learning (content disclosed in the objectives) and/or diminished incidental learning (content not disclosed in the objectives). Three learning levels of BOs—knowledge, comprehension, and application—were distributed to learners before, during and after instruction to determine their effects on relevant and incidental learning.

Two hundred and four tenth-grade students enrolled in 11 classes of physical science served as subjects for the experiment. Nine of the eleven classes were randomly assigned to nine treatments. The remaining two classes were designed a control group. The students in the 11 classes were under the direction of three teachers.

The instructional material consisted of a textual selection of approximately 4700 words from a book titled The Sea. Sixteen concepts were explained in the passage. After the reading passage was selected, the 16 concepts explained in the text were randomly segregated into two groups of eight. The researcher wrote three BOs for each of the eight relevant concepts. The test consisted of three subtests of relevant learning, and three subtests of incidental learning. The test-retest reliability of the six subtests ranged from 0.35 to 0.50.
The experiment took place on two consecutive days. On the first day all students read the textual selection. Students in the treatment groups were given either eight knowledge, eight comprehension or eight application objectives. The time of learner possession of objectives, one level of this treatment factor consisted of showing the objectives to subjects before instruction, and then taking the objectives away before instruction began. A second level consisted of presenting objectives to subjects before instruction, and allowing subjects to keep the objectives during instruction. The third level consisted of revealing the objectives to subjects after instruction had been completed. The achievement test was administered the next day. One month later, the same achievement test was administered again to test retention.

The result of the two posttests were analyzed separately, using multivariate analysis of variance and covariance. For analysis the experiment was considered a 3x3x2 factorial design, with repeated measure of the last factor. The last factor included six subtests of relevant and incidental learning. Verbal scores and reading scores were used as covariates. The analysis of the immediate posttest disclosed no significant differences in learning among the various treatment groups. The analysis of the delayed posttest revealed that there was no significant main effect.
Schneiderwent (1970) used a pretest-posttest control group design to conduct a study to determine the effect of behavioral objectives on student achievement in Harvard Project Physics and to determine student and teacher reaction toward the use of behavioral objectives.

The population consisted of 341 students enrolled in HPP physics classes at seven schools located across the country. One hundred seventy three students in selected schools comprised the experimental group. One hundred sixty-eight students in the same schools comprised the control group.

The behavioral objectives were constructed by the experimenter using guidelines suggested by Mager (1962) and sent to a panel composed of experienced HPP teachers on the high school and college levels to establish content validity. The achievement test was constructed by a HPP test construction group. Reliability was determined to be 0.798 by the split-half method. The content validity of the test items was assumed because they had been supplied by a panel of experts composed of the HPP test group and approved by the Editorial Committee of HPP.

The experimental and control groups in each school were taught by the same teachers. Teachers were instructed to teach both groups in their normal manner, using the
objectives as a supplement with the experimental group. The posttest was administered after the last day of instruction. The attitude instrument was administered to students and teachers.

An analysis of covariance revealed no statistical evidence which indicated any difference between the mean scores of the experimental and the control groups on the posttest. There was a significant difference between the mean scores of boys in the experimental and the control groups at 0.05 level. But, no significant difference was found for girls. It was concluded that the experimental method of instruction proved to be more effective than the conventional method of instruction for boys, but both methods were equally effective for girls. Boys achieved significantly higher than girls at the 0.05 level in both the experimental and control groups. Student and teacher attitude was favorable toward the use of behavioral objectives.

Hershman (1971) conducted a study to investigate the utility of advance organizers and BOs in a traditional introductory physics class at the college level. The sample consisted of 140 students enrolled in Physics 205. The experimental treatments on which this experiment was based consisted of the distribution of three types of materials designed to aid in the student's study. A statement of the intent of the materials was given orally by each instructor.
to the students; a similar statement was included in the body of the instrument. The students were told to use the instruments in their assignment and test preparations. After the appropriate instruction period these students were tested by examinations base on the BOs.

The five tests employed to measure student achievement were constructed by one instructor with the aid of the professor in charge. The objectives of the respective content areas served as a basis for the corresponding tests which were given at intervals between treatments. The Kuder-Richardson formula 20 reliability index ranged from 0.69 to 0.80.

A one-way analysis of covariance with multiple covariates of the resulting treatment group scores was used to compare the effects of treatments. The first examination in the class was used as a covariate to equate the treatment groups on instructor effects. SAT scores were used as a covariate to equate groups on general ability. No significant differences were found that could be attributed the treatment effects with assurance.

Koch (1972) conducted a study to examine possible relationships between Projects Physics students' use of BOs and achievement, appropriateness of confidence, retention, and classroom learning environment. Four hundred eighty eight students from 14 schools participated in the study. In each school intact sections were randomly assigned to the
experimental group (254 students) or control group (234 students). Fourteen teachers volunteered to participate, and each teacher taught a control and experimental group.

The data gathering instruments included the Project Physics tests, the Appropriate Confidence Scoring System (ACSS), and the Learning Environment Inventory (LEI). The Project Physics tests were used to measure achievement. The test had been developed and revised by the staff of Project Physics and approved by the codirectors of the Projects. Their reliability coefficients ranged from 0.744 to 0.831 for the sample included in this study. Students in experimental groups were given a list of the behavioral objectives for Units Two and Three of the Project Physics Course. Students were instructed in the purpose and use of the BOs. They were asked not to show the list of BOs to students in other classes. Near the end of the experiment, the learning Environment Inventory was administered to students. Approximately 60 days after completion of the treatment a retention test was administered to all students.

Data were analyzed first for all 488 students in 28 classes. Next, data were analyzed for selected students, i.e., those in the experimental group who claimed to have used the list of objectives during both units and those in control group who claimed they made no use of the list during both units. The basic statistic used with
achievement and retention tests for both conventional and appropriateness-of-confidence scores was the part point biserial correlation coefficient. The following results were reported:

1. No significant differences between the experimental and control groups were found in achievement or retention scores when a conventional scoring system was used.

2. A correlation coefficient of 0.49 was found between membership in the selected experimental or control group and the Unit Three Test score when an appropriateness-of-confidence scoring system was used.

3. Students in the experimental group who made use of their list of BOs as an aid to study for both Units Two and Three rated the objectives significantly more helpful than did those in the experimental group who did not make use of their list.

4. There were no significant differences between the experimental and control groups on any dimension of classroom learning environment.

The researcher concluded that these findings seemed to indicate that the use of BOs by students yielded benefits in terms of appropriateness-of-confidence, but not in terms of achievement alone.

Mottillo (1973) conducted a study to compared the achievement and attitudes of grade 12 PSSC physics students when they were given lists of BOs as compared to when they
were not given these lists prior to instruction. Five class sections of 25 students each were selected for this study. All students who were assigned to four of the classes participated alternately as members of the treatment and of the control groups. The fifth section remained a control group throughout the period of study. All classes were taught by the same physics teacher.

The investigation was conducted over a 20 week period with no difference in the treatment of any of the classes during the first ten weeks. The second ten weeks, treatment consisted of distributing lists of performance objectives to students in the experimental groups at the beginning of each new chapter. Following the study of each chapter, students were given a short criterion test. An achievement test prepared by the teacher was given upon completion of a unit.

An analysis of variance was used first as the statistical test for testing the null hypotheses at the 0.05 and 0.01 levels of significance. A t-test was then used for testing the null hypotheses at several levels of significance (0.005-0.40). The following results were reported:

1. The hypothesis stating that there is no significant difference, as measured by short criterion test items between the performance of students provided with behavioral objectives prior to instruction and that of students not provided with the behavioral objectives was rejected in
seven instances and not rejected in 35 cases when the analysis of variance was used. The same hypothesis was rejected 22 times and not rejected 20 times with the t-distribution.

2. The hypothesis that there is no significant difference, as measured by teacher's unit tests between the performance of students when they are provided with behavioral objectives prior to instruction as opposed to the performance of students not provided with BOs was rejected six times and not rejected in 10 cases when the analysis of variance was used. The same hypothesis was rejected 10 times and not rejected four times with the t-distribution.

Goel (1980) determined the effectiveness of student prior knowledge of specific behavioral objectives of selected high school physics experiments in the acquisition of psychomotor, different levels of psychomotor and related cognitive skills associated with laboratory work. The research sample comprised 28 schools, from which 14 schools (218 students) were randomly assigned to the treatment. The remaining 14 school (212 students) comprised the control group. Twenty eight teachers participated in this study.

The researcher identified the Intended Specific Behavioral Objectives (ISBO) for each experiment included in the study. The ISBO were validated by a panel of physicists, physics teachers, students, and evaluation specialists. The validation by students established that each student
understood each objective in terms of what it specified them to learn, know or do.

The Perez Test of Science Process (PTSP, Perez, 1979) was used to measure the science processes of students entering the study. The reliability was 0.83 (Indian students). A physics Laboratory Performance Test (PLPT) based on the psychomotor and related cognitive ISBO was designed by the researcher. The content validation was carried out by physicists, evaluation specialists and experienced physics teacher having background in evaluation. The PLPT has two parts. The reliability of Part A was 0.86, and the reliability of Part B was reported 0.88.

The students assigned to the experimental group were provided with the ISBO along with the laboratory manual. The students assigned to the control group performed the experiments without using ISBO. The both groups were also informed that they would have a test after they completed all five experiments.

The data were analyzed using analysis of covariance. A significant difference was found between the adjusted means of the psychomotor achievement scores of the experimental group and control group at 0.05 level. Significant differences were found between the experimental and control groups in the achievement of different levels of psychomotor skills as measured by the adjusted mean scores for achievement at the skill levels of translation, guided
response, mechanism, and complex overt response. There was, however, no significant difference in achievement of the psychomotor skill level of visual discrimination between the two groups. A significant difference was found in the adjusted mean scores of the related cognitive skills for the experimental group and control group. The researcher reported that the lack of any significant difference in achievement on the psychomotor skill of visual discrimination could probably be attributed to the following consideration. Visual discrimination was the lowest level skill in the psychomotor domain taxonomy. Therefore, by the time students reach Grade 10 they might have already acquired this skill through prior experiences.

**General Science**

Four studies were identified which investigated the influence of BOs on general science achievement. These included Conlon (1970), Bryant and Anderson (1972), Johnson and Sherman (1975), and Wong (1980).

Conlon (1970) investigated the effects of providing grade seven Intermediate Science Curriculum Study (ISCS) students with prior knowledge of the objectives of instruction upon their performance as compared to grade seven ISCS students not provided with prior knowledge of the objectives. The sample included 433 grade seven students
taught by four teachers in the ISCS trial centers. The researcher revised the BOs for chapter one through eight of Volume I grade seven ISCS study program. The behavioral objectives then were validated by four people including an author of the ISCS core material, two writers of the original ISCS objectives, and a grade seven teacher. The objectives then were given to junior high students for review.

Self-tests (ISCS, 1968a) were used to measure performance on individual chapters. Selected ISCS achievement test items (ISCS, 1968d) were used to measure overall performance on all chapters. The ISCS instructional material allowed each student to proceed through the materials independently. This imposed the requirement that objectives be available to students on an individual basis. The objectives were presented by altering the student text. Because they appeared as part of the text, the objectives were read or not read as the student chose. All students were given a pretest and a posttest composed of selected ISCS achievement test items. Upon completing a chapter, all students took chapter self-tests.

For purposes of the analysis, each student was categorized into high, middle and low ability levels according to his/her score on the California Test of Mental Maturity (CTMM). The data were analyzed using analysis of variance. There was no statistically significant difference
in performance on the pretest between classrooms. The results of posttest indicated that although the grade seven ISCS students with prior knowledge of the objectives of instruction performed slightly higher than the students without knowledge of the objectives, the difference was not statistically significant at the 0.05 level.

Bryant and Anderson (1972) studied the effects of performance objectives on the achievement level of low achieving black inner city pupils and the effects of giving the students performance objectives prior to beginning instruction. Performance in science attributable to the sex of the pupil was also considered.

Two hundred and ten grade eight science pupils in four predominantly black inner city schools participated in the study. Twelve classes were used in which class size ranged from eight to 23 pupils. Six teachers were randomly divided into two equal groups as follows: (a) trained teachers who received instructions on preparing performance objectives and who used them as an instructional technique and (b) untrained teachers who did not receive instruction on preparing performance objectives and whose teaching style was unaltered.

Behavioral objectives were developed by trained teachers. A criterion test was developed by teachers in both groups. Part I (15 items) was developed by untrained teachers while the trained teachers developed part II (15
items). Test items for part II were congruent with the performance objectives developed by trained teachers. The 30 tests items were examined by each group of teachers to establish the content validity of the test.

Each teacher taught two classes. Pupils in one class were given objectives prior to beginning instruction, whereas pupils in the other class were not informed of the objectives. Each class that received the objectives was randomly selected by teachers. In the case of classes given objectives, but taught by an untrained teacher, a teacher who had been trained in the use of BOs explained the use of objectives to those classes.

No significant differences were found among classes with respect to intelligence. Significant differences in performance were not found on the achievement test scores which could be attributed to treatments or to the sex of pupils. Highly significant interaction effect (p<.001) was found between groups of teachers and individual teachers. It was concluded that pupils taught by teachers trained in the use and development of performance objectives performed better on the test and that the achievement level a pupil attains may be greatly influenced by the pedagogical techniques the teacher used during instruction.

Johnson and Sherman (1975) conducted a study to determine if pre-knowledge of BOs affected students' achievement in the ISCS. The sample population consisted of
120 students. One group of students was selected randomly to be the experimental group while the remaining students formed the control group. Students in each group were divided into low and high ability. To determine the similarity of the two groups, students were matched on scores of the Iowa Test of Basic Skills (ITBS), the Stanford Science Test, and the ISCS pretest. The instructor prepared a test based on the objectives of five chapters in the textbook to measure course achievement.

Students in the experimental group were given a list of the BOSs found in the first five chapters of the ISCS material prior to the study of each chapter. These objectives were referred to from time to time as the teacher interacted with the students. The same objectives were withheld from the control group. At the completion of the five chapters both groups were given the same achievement test.

The data were analyzed using a 2x2 factorial design and analysis of variance. The experimental group performed at a significantly higher level than the control group at 0.05 level. The low achievement experimental group performed significantly better than the low achievement control group (at 0.05 level). The researcher interpreted these finding to mean that better students do not require the objectives in advance to achieve well on the examination. It appears quite likely that the better students have the ability to
determine the learning outcomes expected.

Wong (1980) studied the effects of BOs on achievement in science. The effectiveness of the behavioral objectives was further evaluated with and without additional teacher assistance. The study was conducted in one school from each of three different school districts. Three hundred and three students from 12 life science classes were divided into a control group (n=101) in which students were given no objectives, and an experimental group (n=202) in which the students were given objectives. Students in the experimental group were further divided into a group (n=100) in which the students were given accompanying teacher help, and a group (n=102) in which students were given no accompanying teacher help. Three teachers were involved in the study. Each teacher taught at least one control and two treatment groups.

Behavioral objectives written in a Magerian style were designed by the teacher and presented as a study guide. Six lessons were taught, with objectives given to each student in the experiment groups at the beginning of each investigation. The control group did each investigation as prescribed by the program. Instruction for treatment group was similar except the teacher gave continued supportive help and advice on how best to use the study guide. A second treatment group was taught in the same manner except they received a one page study guide before each investigation.
Overall treatments show greatest improvements for the help groups. The no help and control groups showed similar but diminished improvements. The students from one school showed significant positive effects of having study guides over not having them. The researcher concluded that the use of objectives in the form of study guides can help a student improve in academic achievement, because objectives force both the teacher and the student to address themselves to the intent of lesson. The help that the teacher provided is important and can produce improvement in academic achievement, because if a teacher knows specifically what are the intents of a lesson, then these can be translated to the students. A student who has the security of knowing what the teacher wants can improved academically.

Other Science Studies

Dalis (1970) conducted a study to determine the effects of communicating precise instructional objectives on student learning. The study was designed to provide data on whether student achievement can be influenced significantly by providing students, in advance of instruction, information on what is expected of them as an outcome of instruction and to investigate various ways of communicating to students, in writing, that which was to be learned in class. One hundred forty-three students were selected from five tenth-grade
health and safety classes taught by the same teacher. One third of students in each class was randomly assigned to one of three groups. For the two treatment groups, the participants received precisely stated instructional objectives and vaguely stated instructional objectives, respectively. The control group received short paragraphs of health information.

At the beginning of the study students were told that they had been selected to participate in an experiment to determine whether written messages to be given them periodically during a 3-week period would be of any assistance in their classwork.

An analysis of variance was employed. The test data from students who indicated they had gained information from someone else were not included in the analysis. The researcher reported that the very high F ratio, 10.809 (F=4.49; 2, 130 ), clearly showed that there was a treatment effect favoring group one, the group presented with precise instructional objectives prior instruction. The means on the achievement test group one through three were 40.4, 31.4, and 32.1 respectively. No significant difference existed between group two and group three. The average amount of time spent studying among the three groups, however, was not significantly different.

Baker (1976) examined differences in learning achievement attributable to the differential placement of
behavioral objectives in textual material. An additional purpose was to examine the interaction between certain learner characteristics and the various behavioral objectives treatments. Instructional materials on birth control and sexual anatomy were modified by placing behavioral objectives either before, within, or after written textual material. It was expected that these variations in treatment conditions would influence the acquisition of both relevant and incidental information contained in the textual material.

One hundred and ten students were randomly assigned to one of four treatment or a control groups. Students were given aptitude tests representing verbal and memory abilities in addition to the treatment materials and posttest criterion measures. Posttest measures included performance on questions relevant to the BOs and performance on questions which were not relevant to the objectives but could be answered from textual material (incidental questions). It was anticipated that learner aptitudes would differentially affect learner performances under different treatment conditions. Analyses of the data did not reveal significant main effects or significant interactions between aptitude variables and instruction treatments.

Wingard (1976) used a non-equivalent control group design to study the effects of presenting and discussing specific behavioral objectives upon student learning when
materials are presented in a sex education instructional unit to ninth grade health education classes.

A total of 389 students made up the 12 sections in the health class. Through random sampling the sections were divided into experimental and control groups. A random selection was made within the experimental and control groups choosing 240 students, 120 girls and 120 boys, to be utilized in the investigation. Specific behavioral objectives were developed from each unit objective by the investigator covering specific content, the kind of classroom achievement expected of students, conditions to be imposed upon the students, and specific criteria of acceptable performance as prescribed by Mager (1962). The objectives were used by the investigator to develop a 47 item achievement test to measure cognitive learning at the knowledge, comprehension, and application levels. Construct and item validity were established through seven health educators and item analysis. All judges were asked to make a judgement on how well each test item related to the specific behavioral objectives that had been written for the lessons. The reported correlation coefficient for the odd and even numbered item was 0.849. The test was used as a pretest, posttest, and retention test.

Approximately fifteen weeks later the instructional program began in all health classes. The experimental group received instruction in sex education with written and
discussed specific behavioral objectives. The control group received only a copy of the general instructional objectives and a very general statement about the lesson to be taught.

A three-way (sex, ability and treatment) analysis of variance procedure was employed to analyze the results from post-test score. The t-test was employed to calculate the t-ratio for the mean difference between the experimental group and the control group scores obtained on the pretest, delayed posttest. The following results were reported:

1. A statistically significant difference existed among mean scores obtained in favor of the members of the groups receiving specific behavioral objectives prior to instruction when compared to the members of the groups that did not receive specific behavioral objectives.

2. The mean score obtained by members of the specific behavioral objective treatment group on the post-achievement test was significantly greater than the mean scores obtained by members of the control treatment when the members were subgrouped into categories of low, medium, and high I.Q. levels.

3. Significant differences were found between mean scores obtained by the specific behavioral objectives treatment group and the control group when cognitive learning was classified as knowledge in favor of the specific behavioral objectives group.

Edmondson (1978) conducted an investigation to
determine if behavioral objectives provided a more effective approach to teaching and learning pharmaceutical knowledge and performance skills than did general objectives in the pharmaceutical practical experience training environment. The research design comprised three treatment groups utilizing specific objectives and two treatment groups utilizing general objectives. Pretests of general pharmaceutical knowledge and performance skills along with the Wonderlic Personal Test and amount of past experience in pharmacy were used as covariates. The dependent variables were a posttest of performances skills and a test of specific knowledge of pharmaceutical principles.

An analysis of covariance, pos-hoc comparisons utilizing the Scheffe's test and Mewman-Keuls test and pairwise contrasts with alpha at the 0.05 level of probability were utilized to analyze the data. The group that used behavioral objectives scored significantly better than the two treatment groups that used general objectives.

Lynn (1979) used a posttest only control group design to investigate the effects of student ability and prior knowledge of behavioral objectives on achievement, time spent on the learning task, choice of additional learning activities, and attitude toward objectives. The subjects were students from one intact class enrolled in Human Nutrition and Food management 310. Based on GPA, the subjects were divided into two ability levels, low (n=40)
and high (n=40). The students in each level were assigned randomly to one of two groups (n=20, n=20). There was one teacher, the researcher, throughout the quarter.

Fourteen precise instructional objectives and 14 placebo statements were written for the unit. Both were entitled, "Study guide." An achievement test consisting of 50 multiple choice items was developed from the objectives. It was reviewed by a panel of three nutrition experts for content validity. Reliability was reported as 0.736. The retention test was developed consisting of 25 multiple choice items. Items were selected on the basis of content validity and relative difficulty of the items from the experimental unit examination and posttest. Reliability was 0.767.

The subjects were instructed that the class had been selected to participate in a study. Prior to presenting the experimental unit, each student was given written objectives appropriate to the experimental group or placebos. The achievement test was administered during the regular class period at the conclusion of the experimental unit, and the retention test was administered two weeks after the achievement test (immediate posttest). Study time spent on the learning task was determined by a questionnaire following the immediate posttest. The recommended library references used by each student were recorded by the librarian for the duration of the experimental unit up to
the immediate posttest. Student attitude toward objectives was determined by a Likert type rating scales.

Data were statistically analyzed using a two-way factorial analysis of variance (treatment and ability). There was no significant difference between the objectives and placebo groups in posttest means, retention test means, means of study time, and of library references used. Interaction between treatment and ability level was also not significant for these dependent variables.

Miles (1976) used a posttest-only control group design to compare the achievement of students who were furnished behaviorally stated instructional objectives to those given non-behavioral objectives in outline form. Sixty-two students in four introductory geology classes (Geology 101 and 102 consisted of Physical Geology) were used as subjects. Four intact classes were randomly assigned to an experimental group (n=32) and comparison group (n=30). Multivariate analysis of seven demographic variables (age, high school rank, geology pretest, I.Q. score, vocabulary, comprehension, and reading rate) was used to establish the equivalence of both groups.

Two types of instructional objectives were utilized in this study--behavioral and non-behavioral. A geology pretest was devised by the investigator consisting of 40 multiple choice questions. It was made up by randomly selecting four questions from each of ten weekly units. Five short
achievement and comprehensive test were constructed by the investigator. The test questions were drawn from a pool of questions related to the objectives. Kuder-richardson formula 20 reliabilities estimates were calculated to be 0.93 for the comprehensive test and ranged from 0.64 to 0.83 for the short test.

Students were told that they were part of a research project; however, the details were purposely left vague. For each weekly unit of study (one to two chapters), students in the experimental group received objectives stated in behavioral terms. To ensure maximum benefit from the use of the behavioral form, the experimental group received copies of a brief self-instructional unit on how to use BOs. Students in the comparison group were given non-behavioral objectives. Students were simply told that they were receiving a list of what they supposed to know and understand. Subjects were tested at approximately two-week intervals (5 short achievement tests) and were given a comprehensive final exam.

Analysis of Variance revealed that the experimental group achieved significantly higher than the comparison group on test I and III at 0.05 level. Differences on the other four tests were in favor of the experimental group but below the level of significant. Multivariate analysis indicated that the overall achievement of the experimental group was significantly higher than that the comparison
group at the 95% confidence level.

The reported findings of the previous 39 studies, which examined the influence of behavioral objectives on student achievement in science, were found to be inconsistent and inconclusive. Significant increases in student achievement as a result of the use of behavioral objectives were reported in 14 studies, while 25 studies reported no significant treatment effect.
Summary

This chapter focused on the research reports in which the influence of behavioral objectives on student achievement in science was examined. A review of these studies revealed that no reported studies could be found which related behavioral objectives to learning effectiveness in laboratory or class and laboratory setting in chemistry. It further revealed a need to conduct research on the effect of behavioral objectives on student achievement in the chemistry laboratory as well as the classroom.
CHAPTER III

METHODOLOGY

This chapter provides a description of the methodology used in this study. It consists of the following sections: (a) Experimental design, (b) Selection of sample, (c) Instruments, (d) Procedures, and (e) Statistical Analysis.

Experimental Design

The research design used in this study was a pretest-posttest control group design (Campbell & Stanley, 1963) in which the intact groups constitute naturally assembled classes. With subjects in pre-assembled classes it was necessary to randomly assign the treatments to the intact classes. The experimental design could be diagrammed as follows:

\[
\begin{align*}
R & \quad O_1 \quad X_0 \quad O_2 \\
R & \quad O_1 \quad X_1 \quad O_2
\end{align*}
\]

Where: \( R \) = random assignment to treatments
\( X_0 \) = control group
\( X_1 \) = experimental group
\( O_1 \) = observation (pretest)
\( O_2 \) = observation (posttest)
Behavioral objectives served as the independent variable. The dependent variable was student achievement as measured by a teacher-made achievement test (an objectives-referenced test).

Selection of Sample

The population of this study was composed of 244 students from 12 sections who were taking the first year chemistry at Chulachomklao Royal Military Academy, Thailand. There were random assignment of intact classes to four different treatment groups. According to Cohen's (1969) sample size table, the minimum sample size required when \( \gamma = 0.30 \), \((1-\beta)= 0.80\) and significance level of 0.05 is 27 subjects per treatment for four treatments. So 54 students (three sections) per treatment was enough for this study.

Instruments

The instruments used in the study were as follows: (1) Behavioral Objectives, (2) Achievement Tests in Chemistry. Behavioral objectives were administered prior to instruction for each of units. Achievement tests were administered as posttest at the end of the study period.
Development of Behavioral Objectives

The behavioral objectives used in this study were developed according to the criteria suggested by Mager (1962). The objectives were obtained from general chemistry texts, laboratory manuals, solution manual which accompanies the text, and instructor's manuals or written from a review of behavioral objectives in chemistry which could be found in current literature. The behavioral objectives were designed to correspond to the assigned subject matter. Each behavioral objective used was classified by Bloom's Taxonomy (Bloom, 1956). The behavioral objectives prepared for this study were limited to the knowledge, comprehension, and application level of cognitive domain (Bloom, 1956).

The behavioral objectives were validated and checked for reliability by a modified procedure suggested by Shields (1973) and Goel (1980). This method involved the selection of a panel of judges which independently evaluated the behavioral objectives. This evaluation was done for three aspects:

1). To establish that the behavioral objectives identified by the researcher were the intended objectives for the chemistry class and laboratory for which they were identified.

2). To establish that the behavioral objectives were interpreted the same way by the readers (reliable behavioral
3). To establish that students understood each objective in terms of what it specified them to learn, to know or to do.

To establish the first and second aspects, five chemistry teachers at CRMA were asked to read each objective and on the basis of the course content, decide whether that were the intended objectives for chemistry course. The researcher used some of the ideas suggested by Shields (1973). He devised a checklist of criteria upon which the teachers could evaluate behavioral objectives. The checklist was designed to consider: the interpretation of the objective, clarity, and statement of the objective in behavioral terms that could be evaluated for achievement. The checklist items are shown on appendix A, page 150. The information obtained from the judges was used to trace difficulties of some objectives and then to make revisions.

In order to establish the third aspect of behavioral objectives, 24 students (two students from each section) were asked to read each objective and to decide what each objective intend them to know, learn, or do. Then, a final list of behavioral objectives was developed for issuance to treatment groups. A total of 21 behavioral objectives were constructed for electrochemistry unit and 25 behavioral objectives were constructed for acid-base unit. A total of seven behavioral objectives were constructed for
electrochemistry laboratory and nine behavioral objectives were constructed for acid-base laboratory.

The non-behavioral objectives were constructed from the final list of behavioral objectives. Each of the non-behavioral objectives corresponded to a behavioral objective covering the same content.

The behavioral objectives and non-behavioral objectives were separately prepared for both classroom and laboratory instruction. The lists of objectives are shown in appendix B on page 152.

**Achievement Tests in Chemistry**

The criterion instrument in this study involved the use of a teacher-made achievement test in chemistry. The teacher-made achievement test consisted of multiple-choice test items which were developed to assess the achievement of the behaviors specified by behavioral objectives. The test items were constructed from: content specified in the chemistry textbook, laboratory manual, and selected items from past examinations and from the related published tests. Test items were constructed and selected to closely correspond to the behavioral objectives but not to be identical to the objectives. The behavioral objectives associated with test items is shown in appendix C on page 166. Using the method described by Gronlund (1981) the test
items were constructed, selected, and examined so as to weight the content in accordance to the importance of each of the behavioral objectives. This procedure made use of a matrix to relate test items to the objectives and subject matter content. The matrix (Table of specification) is shown in appendix D on page 168. The numbers in the matrix were the test items that correspond to a particular behavioral objective and a certain area of subject matter. As could be noted in the matrix, it was not necessary that the various content topics received the same number of items. The numbers of items per topic depended on the emphasis in instruction. The extent to which content was divided into topics was an arbitrary decision made by the teacher.

These instruments were administered as a posttest at the end of the study. The content validity was also established by five chemistry teachers at CRMA. Each teacher received the following items for evaluation of a set of test items: a final list of behavioral objectives; a copy of constructed test items; and a matrix relating test items to behavioral objectives and subject matter content. After any needed revision, the final draft of teacher-made test items was prepared. A total of 35 items was constructed for classroom examination. A total of 17 items was constructed for laboratory examination. The test items are shown in appendix E on page 171.
Reliability

Reliability of the teacher-made achievement test was determined by using Kuder-Richardson formula 20 (Wiersma, 1985).

\[ KR_{20} = \frac{n}{(n-1)} \left( \frac{SD^2 - \Sigma pq}{SD^2} \right) \]

where \( n \) = the number of items on the test.
\( SD^2 \) = the variance of scores
\( p \) = the difficulty level of each item or the proportion of the group that responded correctly.
\( q \) = the proportion that missed the item \((1-p)\).

Students' scores on the chemistry achievement test were used to determine the reliability. The reliability of classroom posttest was found to be 0.83. The reliability of laboratory posttest was found to be 0.79. A value of 0.75 was set as the stated value of acceptance. This level of acceptance was recommended by Borg (1989).

Questionnaire

A questionnaire to be used at the end of the study was designed, in part, to determine, the extent to which students in both groups used the objectives. The questionnaire items are shown in appendix F on page 188.
Procedures

Class sections were assigned at random to three different treatments and one control group. The treatment for Experimental Group I involved providing the students with prior knowledge of behavioral objectives for both classroom and laboratory prior to instruction for each of units. Treatment of Experimental Group II involved providing the students with prior knowledge of behavioral objectives for classroom instruction and non-behavioral objectives for laboratory instruction prior to instruction for each of units. Treatment of experimental Group III involved providing the students with prior knowledge of non-behavioral objectives for classroom instruction and behavioral objectives for laboratory instruction prior to instruction for each of units. The control group received non-behavioral objectives for both classroom and laboratory instruction prior to instruction for each of units. The treatment and control groups studied the same subject matter, received the same lecture-discussion examples, received the same problem assignments, and conducted the same experiments in the laboratory. Summary of treatments is shown in Table 1 (page 94).

A list of objectives was distributed with unit assignment to each student prior to the beginning of each unit. The students were told to use the list to organize
knowledge obtained from reading the textbook, lecture, use it in the laboratory while subject matter was presented, and to aid in reviewing for the tests. Students were informed they would complete a test base on the objective provided. They were asked not to share the objectives to students in other section. They were not informed that they were selected to participate in an experiment.

The investigation was conducted during the first eight weeks of the 1990 second semester in CRMA. Each class section attended two-one hour and a half lectures each week taught by six chemistry teachers including the researcher. Each class section met for one-three hours laboratory for each unit of study.

Table 1

Summary of treatment

<table>
<thead>
<tr>
<th>Class</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>BO</td>
</tr>
<tr>
<td>Group II</td>
<td>BO</td>
</tr>
<tr>
<td>Group III</td>
<td>non-BO</td>
</tr>
<tr>
<td>Control</td>
<td>non-BO</td>
</tr>
</tbody>
</table>

Note: BO = behavioral objectives

non-BO = non-behavioral objectives
Statistical Analysis

The primary purpose of this study was to determine the effects of providing behavioral objectives prior to instruction on the achievement of students in a one-semester college general chemistry course and to determine the effect of providing behavioral objectives of selected chemistry experiments in the acquisition of achievement associated with laboratory work.

One-way analysis of covariance was used to analyze the achievement test scores of students in three different treatments and one control group. Additional analysis based on Scheffe's test for multiple comparisons for evaluating the differences between various pairs of treatment achievement test scores. The first semester final exam scores served as covariate. The null hypothesis for the analysis was as follow:

There is no significant treatment effect.

\[ \sigma^2_T = 0 \]

The mathematical model for testing this hypothesis was:

\[ Y_{ij} = \mu + \alpha_j + \beta(X_{ij} - X) + \epsilon_{ij} \]

\[ \mu \] = a fixed constant representing the overall mean

\[ \alpha_j \] = the effect of the treatment

\[ \beta(X_{ij} - X) \] = the adjustment of the postmeasure

\[ \epsilon_{ij} \] = a residual variable (NID, 0, \( \sigma^2 \)) or error term
Table 2 shows the one-way analysis of covariance for analyzing the first to sixth hypotheses.

Table 2
One-way analysis of covariance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f.</th>
<th>SS</th>
<th>MS</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td>1</td>
<td>A</td>
<td>A/1</td>
<td>A/MSE</td>
</tr>
<tr>
<td>Treatments</td>
<td>3</td>
<td>B</td>
<td>B/3</td>
<td>B/3MSE</td>
</tr>
<tr>
<td>Error</td>
<td>215</td>
<td>C</td>
<td>C/215=MSE</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>219</td>
<td>D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Treatments- four levels (treatment I, II, III and control)

The F-ratio was calculated according to the following formula:

\[ F = \frac{\text{MS treatment}}{\text{MS error}} \]

A 0.05 level of significance was used as a basis for rejecting the hypotheses.

Post hoc analysis based on Scheffe's test for multiple comparisons for evaluating the differences between various pairs of achievement test scores. The formula is shown
below.

\[ S_c = \frac{[x_a - x_b]}{\left( \text{MSE} \left( \frac{1}{n_a} + \frac{1}{n_b} \right) \right)^{1/2}} \]

\[ S_t = \left( (k-1) F_{(k-1, n-k, \alpha)} \right)^{1/2} \]

\( x_a \) = mean scores of group a
\( x_b \) = mean scores of group b
\( n_a \) = number of students in group a
\( n_b \) = number of students in group b
\( n \) = total number of students
\( k \) = total number of groups
\( \text{MSE} \) = mean squares error.

The null hypothesis was rejected when \( S_c > S_t \).

One-way analysis of covariance was used to analyze the achievement scores of students in classroom and laboratory instruction. The first semester final exam scores served as the covariate. The null hypothesis for the analysis was as follow:

1. There is no significant treatment effect.

\[ \sigma^2_T = 0 \]
Table 3 shows the one-way analysis of covariance for analyzing the seventh and eighth hypotheses.

**Table 3**  
One-way analysis of covariance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f</th>
<th>SS</th>
<th>MS</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td>1</td>
<td>A</td>
<td>A/1</td>
<td>A/MSE</td>
</tr>
<tr>
<td>Treatments</td>
<td>1</td>
<td>B</td>
<td>B/1</td>
<td>B/MSE</td>
</tr>
<tr>
<td>Error</td>
<td>217</td>
<td>G</td>
<td>G/217=MSE</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>219</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Treatments - two level (BO and non-BO)

The F-ratio was calculated according to the following formula:

\[ F = \frac{\text{MS treatment}}{\text{MS error}} \]

A 0.05 level of significance was used as a basis for rejecting the hypotheses.
Summary

Chapter III presented the methodology of the study. It discussed the experimental design, sample selection, instruments, procedure, and statistical analysis.
Chapter IV is organized into four sections. The first lists the research hypotheses. The second provides the data and interpretation for testing each of the research hypotheses. The third section covers findings not directly related to hypotheses. The final section includes a summary of the findings.

Research Hypotheses

The research hypotheses tested in this study were as follows:

1. There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction.

2. There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with non-behavioral
objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction.

3. There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

4. There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction.

5. There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

6. There is no significant difference in achievement in general chemistry between students provided with non-
behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

7. There is no significant difference in classroom achievement in general chemistry between students provided with behavioral objectives and students provided with non-behavioral objectives prior to instruction for classroom instruction.

8. There is no significant difference in laboratory achievement in general chemistry between students provided with behavioral objectives and students provided with non-behavioral objectives prior to instruction for laboratory instruction.

Testing the Hypothesis

Hypothesis one to six were tested using a one-way analysis of covariance and the Scheffe's test of multiple comparisons. The first semester final exam scores served as the covariate. The results of the one-way analysis of covariance for chemistry achievement in control and experimental groups are provided in Table 4, while the results of the Scheffe's test of multiple comparisons are presented in Table 5.
Table 4

One-way analysis of covariance for chemistry achievement in treatment and control groups (N=220 students).

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f.</th>
<th>sum of squares</th>
<th>mean square</th>
<th>F-ratio</th>
<th>sign. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td>1</td>
<td>14699.348</td>
<td>14699.348</td>
<td>1171.680</td>
<td>.0000</td>
</tr>
<tr>
<td>Treatments</td>
<td>3</td>
<td>499.291</td>
<td>166.430</td>
<td>13.266**</td>
<td>.0000</td>
</tr>
<tr>
<td>Error</td>
<td>215</td>
<td>2697.289</td>
<td>12.546</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>219</td>
<td>17895.927</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** p< 0.01

From an F table with 3, 200 degrees of freedom, a 2.65 critical F value at the 5 % level of significance was obtained. Since this 2.65 is less than the 13.266 obtained in the one-way analysis of covariance, it can be stated that a significant difference existed at the 0.05 level of significance in the means of the achievement scores of the four groups.

The Scheffe's test was used to determine specifically which mean achievement scores differed significantly. The Scheffe's test of multiple comparisons between the means of achievement scores of the three treatment groups and control group produced the variance ratios (F-ratio) reported in Table 5.
Table 5
Variance ratios from Scheffe's test between three treatment groups and control group.

<table>
<thead>
<tr>
<th>Group comparison</th>
<th>$S_e$</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I and II</td>
<td>1.87/0.68</td>
<td>2.75</td>
</tr>
<tr>
<td>Group I and III</td>
<td>3.17/0.68</td>
<td>4.66**</td>
</tr>
<tr>
<td>Group I and control</td>
<td>5.14/0.67</td>
<td>7.67**</td>
</tr>
<tr>
<td>Group II and III</td>
<td>1.30/0.68</td>
<td>1.91</td>
</tr>
<tr>
<td>Group II and control</td>
<td>3.27/0.67</td>
<td>4.88**</td>
</tr>
<tr>
<td>Group III and control</td>
<td>1.97/0.67</td>
<td>2.94*</td>
</tr>
</tbody>
</table>

** p< 0.01, * p< 0.05

The absolute values of the F-ratio between group comparisons shown in Table 5 were compared with the calculated test statistic of 2.82 ($S_t$). From the data in Table 5, it can be seen that a significant difference existed at the 0.01 level of significance in the means between group I and III comparisons, group I and control comparisons, and group II and control comparisons.
Hypothesis 1

There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction.

Hypothesis 1 was tested using a one-way analysis of covariance and the Scheffe's test. The means and standard deviations of student scores for group I and group II on the general chemistry achievement pretest and posttests are provided in Table 6.

Table 6
Means and standard deviations of the pretest and posttest chemistry scores for group I and II (N=109 students).

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>69.24</td>
<td>1.46</td>
</tr>
<tr>
<td>Posttest score</td>
<td>36.56</td>
<td>1.19</td>
</tr>
<tr>
<td>Group II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>68.70</td>
<td>1.46</td>
</tr>
<tr>
<td>Posttest score</td>
<td>34.69</td>
<td>1.22</td>
</tr>
</tbody>
</table>
The data reported in Table 6 show that the posttest mean scores in general chemistry of students in group I and group II were 36.56 and 34.69 respectively. From Table 4, it can be seen that a significant difference existed at the 0.05 level of significance among the mean scores of the four groups. However, the Scheffe's test results (Table 5) disclosed that the F-ratio (F=2.75) of group I and group II comparison was not found to exceed the calculated test statistic of 2.82. Thus, it was concluded that there was no significant difference between means of group I and group II. Based on these findings, Hypothesis 1 is retained at 0.05 level of significance.

**Hypothesis 2**

There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction.

Hypothesis 2 was tested using a one-way analysis of covariance and the Scheffe's test. The means and standard deviations of student scores in group I and group III on the general chemistry achievement pretest and posttests are
provided in Table 7.

Table 7
Means and standard deviations of the pretest and posttest chemistry scores for group I and III (N=108 students).

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>69.24</td>
<td>1.46</td>
</tr>
<tr>
<td>Posttest score</td>
<td>36.56</td>
<td>1.19</td>
</tr>
<tr>
<td>Group III</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>68.34</td>
<td>1.37</td>
</tr>
<tr>
<td>Posttest score</td>
<td>33.39</td>
<td>1.12</td>
</tr>
</tbody>
</table>

Table 7 shows that the posttest mean scores in general chemistry of students for groups I and III were 36.56 and 33.39 respectively. From Table 5, it can be seen that the F-ratio (F=4.66) of group I and III comparisons was found to exceed the calculated test statistic of 2.82. Thus, it was concluded that the students in group I achieved significantly higher in general chemistry than did students in group III. Based on these findings, Hypothesis 2 was rejected at the 0.05 level of significance.
Hypothesis 3

There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

Hypothesis 3 was tested using a one-way analysis of covariance and the Scheffe's test. The means and standard deviations of student scores for group I and the control group on the general chemistry achievement pretest and posttests are provided in Table 8.

Table 8

Means and standard deviations of the pretest and posttest chemistry scores for group I and control (N=111 students).

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>69.24</td>
<td>1.46</td>
</tr>
<tr>
<td>Posttest score</td>
<td>36.56</td>
<td>1.19</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>67.88</td>
<td>1.58</td>
</tr>
<tr>
<td>Posttest score</td>
<td>31.42</td>
<td>1.26</td>
</tr>
</tbody>
</table>
Table 8 shows that the posttest mean scores in general chemistry of students for group I and control group were 36.56 and 31.42 respectively. From Table 5, it can be seen that the F-ratio ($F=7.67$) of group I and control comparison was found to exceed the calculated test statistic of 2.82. Thus, it was concluded that the students in group I achieved significantly higher in general chemistry than did students in the control group. Based on these findings, Hypothesis 3 was rejected at 0.05 level of significance.

Hypothesis 4

There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction.

Hypothesis 4 was tested using a one-way analysis of covariance and the Scheffe's test. The means and standard deviations of student scores for groups II and III on the general chemistry achievement pretest and posttests are provided in Table 9.
Table 9

Means and standard deviations of the pretest and posttest chemistry scores for group II and III (N=109 students).

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>68.70</td>
<td>1.46</td>
</tr>
<tr>
<td>Posttest score</td>
<td>34.69</td>
<td>1.22</td>
</tr>
<tr>
<td>Group III</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>68.34</td>
<td>1.37</td>
</tr>
<tr>
<td>Posttest score</td>
<td>33.39</td>
<td>1.12</td>
</tr>
</tbody>
</table>

Table 9 shows that the posttest mean scores in general chemistry of students for group II and group III were 34.69 and 33.39 respectively. From Table 4, it can be seen that a significant difference existed at the 0.05 level of significance among the mean achievement scores of the four groups. However, the Scheffe's test results (Table 5) disclosed that the F-ratio (F=1.91) of group II and group III comparison was not found to exceed the calculated test statistic of 2.82. Thus, it was concluded that there was no significant difference between mean scores of group II and group III. Based on these findings, Hypothesis 4 is retained at 0.05 level of significance.
Hypothesis 5

There is no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

Hypothesis 5 was tested using a one-way analysis of covariance and the Scheffe's test. The means and standard deviations of student scores for group II and control group on the general chemistry achievement pretest and posttests are provided in Table 10.

Table 10
Means and standard deviations of the pretest and posttest chemistry scores for group II and control (N=112 students).

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>68.70</td>
<td>1.46</td>
</tr>
<tr>
<td>Posttest score</td>
<td>34.69</td>
<td>1.22</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>67.88</td>
<td>1.58</td>
</tr>
<tr>
<td>Posttest score</td>
<td>31.42</td>
<td>1.25</td>
</tr>
</tbody>
</table>
Table 10 shows that the posttest mean scores in general chemistry of students in group II and control group were 34.69 and 31.42 respectively. From Table 5, it can be seen that the F-ratio (F=4.88) of group II and the control group comparison was found to exceed the calculated test statistic of 2.82. Thus, it was concluded that the students in group II achieved significantly higher in general chemistry than did students in the control group. Based on these findings, Hypothesis 5 was rejected at 0.05 level of significance.

**Hypothesis 6**

There is no significant difference in achievement in general chemistry between students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

Hypothesis 6 was tested using a one-way analysis of covariance and Scheffe's test. The means and standard deviations of student scores for group III and the control group on the general chemistry achievement pretest and posttests are provided in Table 11.
Table 11
Means and standard deviations of the pretest and posttest chemistry scores for group III and control (N=111 students).

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group III</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>68.34</td>
<td>1.37</td>
</tr>
<tr>
<td>Posttest score</td>
<td>33.39</td>
<td>1.12</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>67.88</td>
<td>1.58</td>
</tr>
<tr>
<td>Posttest score</td>
<td>31.42</td>
<td>1.26</td>
</tr>
</tbody>
</table>

From Table 11, it can be seen that the posttest mean scores in general chemistry of students in group III and control group were 33.39 and 31.42 respectively. Table 5 shows that the F-ratio (F=2.94) of group III and control group comparisons was found to exceed the calculated test statistic of 2.82. Thus, it was concluded that the students in group III achieved significantly higher in general chemistry than did students in the control group. Based on these findings, Hypothesis 6 was rejected at 0.05 level of significance.
Hypothesis 7

There is no significant difference in classroom achievement in general chemistry between students provided with behavioral objectives and students provided with non-behavioral objectives prior to instruction for classroom instruction.

Hypothesis 7 was tested using a one-way analysis of covariance. The means and standard deviations of student scores for the experimental and control groups on classroom achievement pretest and posttests are provided in Table 12, while the results of the one-way analysis of covariance are presented in Table 13.

Table 12
Means and standard deviations of student scores on the classroom achievement pretest and posttest in experimental and control groups (N=220 students).

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>68.96</td>
<td>1.03</td>
</tr>
<tr>
<td>Posttest score</td>
<td>24.01</td>
<td>0.61</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>68.10</td>
<td>1.05</td>
</tr>
<tr>
<td>Posttest score</td>
<td>20.14</td>
<td>0.56</td>
</tr>
</tbody>
</table>
Table 13
One-way analysis of covariance for classroom achievement of students in experimental and control groups (N=220 students).

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f.</th>
<th>sum of squares</th>
<th>mean square</th>
<th>F-ratio</th>
<th>sign. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td>1</td>
<td>7420.943</td>
<td>7420.943</td>
<td>1568.120</td>
<td>.0000</td>
</tr>
<tr>
<td>Treatments</td>
<td>1</td>
<td>641.475</td>
<td>641.475</td>
<td>135.550**</td>
<td>.0000</td>
</tr>
<tr>
<td>Error</td>
<td>217</td>
<td>1026.927</td>
<td>4.732</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>219</td>
<td>9089.346</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** p< 0.01

Table 12 reveals that the posttest mean scores on classroom achievement of students in the experimental and control groups were 24.01 and 20.14 respectively. From an F table with 1, 200 degree of freedom, a 3.89 critical F at the 5 percent level of significance was obtained. Since 3.89 is less than the 135.550 obtained in one-way analysis of covariance (Table 13), it can be concluded that students in the experimental group achieved significantly higher in classroom achievement than did students in the control group. Based on these findings, Hypothesis 7 was rejected at 0.05 level of significance.
Hypothesis 8

There is no significant difference in laboratory achievement in general chemistry between students provided with behavioral objectives and students provided with non-behavioral objectives prior to instruction for laboratory instruction.

Hypothesis 8 was tested using a one-way analysis of covariance. The means and standard deviations of student scores for the experimental and control groups on laboratory achievement pretest and posttests are provided in Table 14, while the results of the one-way analysis of covariance are presented in Table 15.

Table 14
Means and standard deviations of student scores on the laboratory achievement pretest and posttest in experimental and control groups (N=220 students).

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>68.79</td>
<td>0.99</td>
</tr>
<tr>
<td>Posttest score</td>
<td>12.71</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest score</td>
<td>68.28</td>
<td>1.07</td>
</tr>
<tr>
<td>Posttest score</td>
<td>11.26</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Table 15

One-way analysis of covariance for laboratory achievement of students in experimental and control groups (N= 220 students).

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f.</th>
<th>sum of squares</th>
<th>mean square</th>
<th>F-ratio</th>
<th>sign. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td>1</td>
<td>1288.087</td>
<td>1288.087</td>
<td>182.812</td>
<td>.0000</td>
</tr>
<tr>
<td>Treatments</td>
<td>1</td>
<td>98.772</td>
<td>98.772</td>
<td>14.018**</td>
<td>.0000</td>
</tr>
<tr>
<td>Error</td>
<td>217</td>
<td>1528.977</td>
<td>7.046</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>219</td>
<td>2915.836</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** p< 0.01

Table 14 reveals that the posttest mean scores on laboratory achievement of students in the experimental and control groups were 12.71 and 11.26 respectively. From an F table with 1, 200 degree of freedom, a 3.89 critical F at the 5% level of significance was obtained. Since 3.89 is less than the 14.018 obtained in the one-way analysis of covariance, it can be concluded that the students in the experimental group achieved significantly higher in laboratory achievement than did students in the control group. Based on these findings, Hypothesis 8 was rejected at 0.05 level of significance.
Reliability of Instruments

The reliability of the general chemistry achievement tests were determined by using the Kuder-Richardson Formula 20 (Wiersma, 1985). The reliability of the classroom posttest was found to be 0.83. The reliability of the laboratory posttest was found to be 0.79.

Findings not Directly Related to Hypotheses

Although not a primary aim of the study, student feedback was obtained concerning the use and perceived value of behavioral and non-behavioral objectives. Students in the experimental and control groups completed short informal questionnaires following the posttest (See appendix F for copy of questionnaires). It should be mentioned that whereas several investigators have reported that some students failed to read or use presented behavioral objectives lists, this was not the case in this investigation. The results of the questionnaires for the experimental group in both classroom and laboratory instruction are shown in Tables 16 and 17.

From Table 16 it can be seen that every student in the experimental group (100%) read and utilized the behavioral objective lists. Ninety-seven percent of the students felt the classroom objectives helped them decide what to study
for the tests. Eighty-nine percent of the students felt the objectives helped make their study time more efficient. Table 17 reveals that every student in the experimental group (100 %) read and utilized the behavioral objective lists. Eighty percent of the students felt the laboratory objectives helped them decide what to study for the tests. Seventy-four percent of students felt the laboratory objectives helped make their study time more efficient.

Table 16
Summary of selected items on questionnaire for behavioral objectives the experimental group (classroom, N=109).

<table>
<thead>
<tr>
<th>Item</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used objectives to study</td>
<td>100 %</td>
<td></td>
</tr>
<tr>
<td>Felt objectives helped in deciding what to study</td>
<td>97 %</td>
<td>3 %</td>
</tr>
<tr>
<td>Felt objectives made study time more efficient</td>
<td>89 %</td>
<td>11 %</td>
</tr>
<tr>
<td>Shared objectives with other students</td>
<td></td>
<td>100 %</td>
</tr>
</tbody>
</table>
Table 17

Summary of selected items on questionnaire for behavioral objectives the experimental group (laboratory, N=108).

<table>
<thead>
<tr>
<th>Item</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used objectives to study</td>
<td>100 %</td>
<td>-</td>
</tr>
<tr>
<td>Felt objectives helped in deciding what to study</td>
<td>80 %</td>
<td>20 %</td>
</tr>
<tr>
<td>Felt objectives made study time more efficient</td>
<td>74 %</td>
<td>26 %</td>
</tr>
<tr>
<td>Shared objectives with other students</td>
<td>-</td>
<td>100 %</td>
</tr>
</tbody>
</table>

The results of questionnaires for the control group in both classroom and laboratory instruction are shown in Tables 18 and 19. From Table 18, it can be seen that 69 percent of the students in the control group felt that the classroom objectives did not help them decide what to study for the test. Seventy-two percent of the students felt that the objectives did not help make their study time more efficient. Table 19, reveals that 73 percent of the students felt that the laboratory objectives did not help them decide what to study for the test. Seventy-five percent of students felt that the objectives did not help make their study time more effective.

One of the primary concerns of the methodology was that
students share the objectives with other students. One questionnaire was designed, in part, to determine the extent of this potential problem. None of the students reported that they shared objectives with other students.

Table 18
Summary of selected items on questionnaire for non-behavioral objectives control group (classroom, N=111).

<table>
<thead>
<tr>
<th>Item</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used objectives to study</td>
<td>100 %</td>
<td>-</td>
</tr>
<tr>
<td>Felt objectives helped in deciding what to study</td>
<td>31 %</td>
<td>69 %</td>
</tr>
<tr>
<td>Felt objectives made study time more efficient</td>
<td>28 %</td>
<td>72 %</td>
</tr>
<tr>
<td>Shared objectives with other students</td>
<td>-</td>
<td>100 %</td>
</tr>
</tbody>
</table>
Table 19
Summary of selected items on questionnaire for non-behavioral objectives control group (laboratory, N=112).

<table>
<thead>
<tr>
<th>Item</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used objectives to study</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>Felt objectives helped in deciding what to study</td>
<td>27%</td>
<td>73%</td>
</tr>
<tr>
<td>Felt objectives made study time more efficient</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>Shared objectives with other students</td>
<td>-</td>
<td>100%</td>
</tr>
</tbody>
</table>

Summary of the Findings

In summary, the findings directly related to the hypotheses were as follows:

1. There was no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction.
2. There was a significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction.

3. There was a significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

4. There was no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction.

5. There was a significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction and students provided with non-
behavioral objectives prior to instruction for classroom and laboratory instruction.

6. There was a significant difference in achievement in general chemistry between students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

7. There was a significant difference in class achievement in general chemistry between students provided with behavioral objectives and students provided with non-behavioral objectives prior to instruction for classroom instruction.

8. There was a significant difference in laboratory achievement in general chemistry between students provided with behavioral objectives and students provided with non-behavioral objectives prior to instruction for laboratory instruction.

A summary of the findings not directly related to the hypotheses were as follows:

1. Every student in both experimental and control groups reported that they read and utilized the objectives.

2. None of the students reported that they shared
objectives with other students.

3. Ninety-seven percent of the students in the experimental group reported that they felt the classroom objectives helped them decide what to study for the test. Eighty-nine percent of the students felt objectives made study time more efficient.

4. Eighty percent of the students in the experimental group reported that they felt the laboratory objectives helped them decide what to study for the test. Seventy-four percent of the students felt objectives made their study time more efficient.

5. Sixty-nine percent of the students in the control group reported that the classroom objectives did not help them decide what to study for the test. Seventy-two percent of the students felt objectives did not make their study time more efficient.

6. Seventy-three percent of the students in the control group reported that the laboratory objectives did not help them decide what to study for the test. Seventy-five percent of the students felt objectives did not make their study time more efficient.
CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study compared student achievement in general chemistry at the university level under the effects of providing behavioral objectives and non-behavioral objectives prior to instruction in both classroom and laboratory instruction. This chapter is organized into four sections. The first summarizes the study. The second presents a summary of findings and the conclusions. Section three provides a discussion of the findings. The final section is devoted to recommendations and suggestions for future research and practice.

Summary

The purpose of this study was to determine the effects of providing behavioral objectives prior to instruction on the achievement of students in a one-semester college general chemistry course and to determine the effect of providing behavioral objectives of selected chemistry experiments in the acquisition of achievement associated with laboratory work.

The population of the study was composed of 244 college students from 12 sections taking first-year chemistry in the
second semester (CH 102). Twelve sections were assigned at random to three different treatments and one control group. The treatment for Experimental Group I involved providing the students with prior knowledge of behavioral objectives for both classroom and laboratory prior to instruction for each of two-four week units. Treatment of Experimental Group II involved providing the students with prior knowledge of behavioral objectives for classroom instruction and non-behavioral objectives for laboratory instruction prior to instruction for each of units. Treatment of experimental Group III involved providing the students with prior knowledge of non-behavioral objectives for classroom instruction and behavioral objectives for laboratory instruction prior to instruction for each of units. The control group received non-behavioral objectives for both classroom and laboratory instruction prior to instruction for each of units.

A list of objectives was handed out to each of these students prior to the beginning of each unit (See appendix B). The behavioral objectives were developed according to the criteria identified by Mager (1962). They were limited to the knowledge, comprehension, and application level of cognitive domain (Bloom, 1956).

The behavioral objectives were validated and checked for reliability using a modified procedure suggested by Shields (1973) and Goel (1980). This method involved the
selection of a panel of judges which independently evaluated the behavioral objectives. A total of 21 behavioral objectives was constructed for the electrochemistry unit and 25 behavioral objectives were constructed for acid-base unit. A total of seven behavioral objectives were constructed for electrochemistry laboratory and nine behavioral objectives were constructed for acid-base laboratory. The non-behavioral objectives were constructed from the final list of behavioral objectives. Each non-behavioral objective corresponded to a behavioral objective.

The students were given the teacher-made achievement test in chemistry at the end of study period. The teacher-made achievement test consisted of multiple-choice test items which were developed to assess the achievement of the behaviors specified in the behavioral objectives. The test items were constructed from content specified in the chemistry textbook, laboratory manual, and selected items from past examination and from the related published tests. Test items were constructed and selected to closely correspond to the behavioral objective but not to be identical to the objectives. Using the method described by Gronlund (1981) the test items were constructed, selected, and examined so as to weight the content in accordance to the importance of each of the behavioral objectives. A total of 35 test items was constructed for the classroom examination, and a 17 item test was constructed for the
laboratory examination. Reliability of the teacher-made achievement tests was determined using Kuder-Richardson formula 20.

The statistical methods used to analyze the data consisted of two techniques. A one-way analysis of covariance was used to analyze student achievement test scores in three different treatments and one control group. Scheffe's test for multiple comparisons was used for evaluating the differences between various pairs of treatment achievement test scores. A one-way analysis of covariance was used to analyze the achievement scores of students in the classroom and laboratory. The first semester final examination scores served as pretest scores.

Findings and Conclusions

In summary, the findings directly related to the hypotheses were as follows:

1. There was no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction.
2. There was a significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction.

3. There was a significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom and laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

4. There was no significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction.

5. There was a significant difference in achievement in general chemistry between students provided with behavioral objectives prior to instruction for classroom instruction and non-behavioral objectives prior to instruction for laboratory instruction and students provided with non-
behavioral objectives prior to instruction for classroom and laboratory instruction.

6. There was a significant difference in achievement in general chemistry between students provided with non-behavioral objectives prior to instruction for classroom instruction and behavioral objectives prior to instruction for laboratory instruction and students provided with non-behavioral objectives prior to instruction for classroom and laboratory instruction.

7. There was a significant difference in class achievement in general chemistry between students provided with behavioral objectives and students provided with non-behavioral objectives prior to instruction for classroom instruction.

8. There was a significant difference in laboratory achievement in general chemistry between students provided with behavioral objectives and students provided with non-behavioral objectives prior to instruction for laboratory instruction.

From the findings it was concluded that providing students with behavioral objectives prior to instruction did significantly enhance achievement in chemistry, as compared with providing students with non-behavioral objectives prior to instruction in both classroom and laboratory instruction. This conclusion was limited to the Chulachomklao Royal Military Academy, Thailand and any similar situation and
groups that may exist.

Discussion

The results of this study regarding the effects of behavioral objectives on student achievement in chemistry differ from results of the earlier studies of Olsen, M.D. (1987), Payne (1970), Boardman (1970), Herron (1971), Pfister (1981), and Rickard (1985), where the strategy of providing students with behavioral objectives did not enhance achievement in chemistry. The difference between the results of this study and the six previous studies in chemistry might have been the result of differences in the design and methodology.

In the study of Boardman (1970), the reason for using the objectives was not presented to the students. The students with objectives did not know for sure that the objectives would help them to organize knowledge obtained from the class. The researcher did not provide any information on validity and reliability of the test instrument. The testing instrument might not have been sensitive enough to detect the difference between groups.

In a well designed study of the effect of behavioral objectives on student achievement in college chemistry, Herron (1971) found a significant increase in performance on one of three tests for students using behavioral objectives
when compared with a control group without objectives. However, this researcher did not control the content in recitation. No data were obtained as to whether the students actually used the objectives.

Payne (1972) investigated the possible effect that the use of behavioral objectives would have on the achievement of high school chemistry students. Payne reported that the objectives were written from the implied objectives in the teacher's guide and the achievement test prepared for the text. The instruments used for measuring the achievement of each group were designed to measure only recognition and recall of facts and concepts discussed within the chapter. Students in the experimental group did not always understand each objectives in terms of what it specified them to learn, to know or to do. Only 13 % of the students in the experimental group indicated that the objectives were clear enough for them to understand and follow without teacher's help. Payne used pretest-posttest experimental design, however the pretest scores were not used as the covariate for statistical analysis.

Pfister (1981) conducted a study to determine the effect of providing and using behavioral objectives on the achievement of students in a one-semester college general chemistry course. The subjects included 61 students enrolled in three sections. The sample size was relatively small for this study. Pfister reported that 89 % of the students used
the objectives to study for the first unit test, while 80% used the objectives to study for the second unit.

Rickard (1985) determined the effect of behavioral objectives or behavioral objectives in conjunction with instructional objectives on the performance of a college general chemistry class. Rickard reported that not all students in the treatment group used the objectives and therefore did not really receive the treatment, thus making the difference in the mean scores too small to observe. Only 5.7% of the students who received behavioral objectives used the objectives extensively while 45.7% used the objectives to some extent, and 48.6% did not use the objectives at all.

Olsen, M.D. (1987) determined the effects of various presentations of objectives on learning a set of four acid-base chemistry lessons presented on a microcomputer interactive videodisc system. In this study, students were given the pretest six weeks before the study began, resulting in a history effect. The study was conducted for six class periods.

In this study, providing students with behavioral objectives prior to instruction did significantly enhance achievement in chemistry, as compared with providing students with non-behavioral objectives prior to instruction. This finding is consistent with several earlier studies (Dalas, 1970; Edmonson, 1978; Goel, 1980; Hass,
which investigated the effect of behavioral objectives on student achievement in other science subjects.

Providing students with behavioral objectives may enhance achievement for the following reasons:

1. Students have a much better idea of what is expected of them and need not be hindered by the limitations of their teachers (Sheehan, 1974).

2. Students can distinguish between what is relevant and what is irrelevant (Towle and Merrill, 1975; Ausubel, 1960).

3. Objectives help the learner identify the terminal behavior desired by the instructor (Gagne, 1962).

4. Objectives assist students in organizing their own learning activities (Gagne, 1965).

5. Objectives facilitate the learner's organization of knowledge, which would direct his thinking to the learning task (Forgus, 1966).

6. Objectives can be made the basis of individualized instruction because they do give the learners goals to achieve and direction as they process through the instruction (MacDonald-Rose, 1973).

The observed effectiveness of providing students with behavioral objectives prior to instruction on student
achievement in chemistry found in this study may be the results of one or a combination of several of the following related factors discussed below.

1. The behavioral objectives might have provided a stimulus to students by pointing out the direction and as a clue to what they were expected to do. Thus the knowledge of behavioral objectives by students in the experimental group students might have helped them to discriminate between important and unimportant learning material. Student attention was therefore focussed on the important learning tasks and hence resulted in better achievement.

2. Students who formed the sample of this study were exposed to behavioral objectives for the first time in their schooling. At CRMA behavioral objectives are not provided to students. It is possible that significant differences might have been produced as a result of the novelty of the learning experience for the experimental group students as implied by the Hawthorne studies (Snow, 1927).

3. In this study, in keeping with the advice of Tiemann (1968), all students were informed that the posttest would be based on the objectives provided. This information might have allowed them to make conscious efforts to achieve the objectives. However, students who were given the behavioral objectives might have a much better idea of what was expected of them than students who were given the non-behavioral objective so that they could obtain better scores.
on the test.

In the judgment of the researcher the one factor which most directly contributed to the improved achievement of the experimental group students was the role of behavioral objectives served in providing stimulus and feedback to students. It can be seen that the results of questionnaires for the experimental group (Tables 16 and 17) reveal that every student read and utilized the behavioral objective lists. Ninety-seven percent of the students reported that the classroom objectives helped them decide what to study. Eight-nine percent of the students reported that the classroom objectives helped make their study time more efficient.

Even though statistically significant differences were found between the experimental and control groups through the application of the strategy of providing students with behavioral objectives prior to instruction, the question arises as to how important these differences are from a pedagogical point of view. Are the differences substantial enough to justify the time and effort required to identify the objectives and provide them to students? A review of Table 12 (page 114) reveals that the mean classroom achievement score of students in the control group was 20.14 (57.54 %) out of a maximum of 35 and that of the experimental group was 24.01 (68.60 %). This means that by providing behavioral objective prior to classroom
instruction, the mean score on classroom achievement was improved by 3.87 points, about a 11% increase.

Similarly if we review the mean scores of both the experimental and control groups on laboratory achievement (Table 14, page 116) we find that the mean scores for the control and experimental groups are 11.26 (66.24%) and 12.71 (74.76%) respectively. In this case the increase in the mean score of the experimental group as a result of providing behavioral objective prior to laboratory instruction is 1.45 points, about a 9% increase.

The researcher feels that an improvement of 11 percent in the classroom achievement and nine percent in laboratory achievement of students in general chemistry as a result of providing students with behavioral objectives prior to instruction is a substantial improvement in student achievement. The strategy of providing students with behavioral objectives prior to instruction may thus have substantial practical significance for curriculum framers and teachers at CRMA. It implies that the curriculum framers, while developing a chemistry and/or other science courses, should identify the specific behavioral objectives of course, and the teachers should provide the behavioral objectives to students prior to instruction. The use of behavioral objectives may best be considered as only one of several methods or tools by which teachers may attempt to increase the achievement of students.
Recommendations and Suggestions for Research and Practice

Practice

The results of this investigation suggest that science teachers can facilitate learning if they (1) provide students with a suitable list of behavioral objectives prior to instruction; (2) ensure that students actually understand each objective in terms of what it specifies for them to learn, to know or to do; and (3) ensure that students know the reason for using the objectives and encourage them to use these objective to organize knowledge.

The improvement of almost 4 points or 11 percent in the classroom achievement and almost 1.5 points or 9 percent in the laboratory achievement of students in general chemistry as a result of providing students with behavioral objectives prior to instruction is a substantial improvement in student achievement. Such improvement with relatively little effort or change is of practical significance. The teacher must carefully weigh the value of using behavioral objectives against the time spent in developing and distributing them to the students. Some teachers might better spend the time in preparing their presentations and in better introducing their topics to the students before preparing and using behavioral objectives.

Academic achievement is one of the major goals of any school system, especially at the college and university
levels in Thailand. The results of this study support the proposition that providing students at the university level with behavioral objectives prior to instruction helps to achieve this goal. Since the CRMA school system is different from other school systems in Thailand, implementing the strategy of providing students with behavioral objectives prior to instruction in the other school systems may not be an easy matter. It is suggested that additional study should be undertaken regarding the effects of behavioral objectives on achievement in chemistry in other school systems. The findings of these studies may provide further support for providing behavioral objectives in chemistry classes.

**Future Research**

The following are recommended for future research.

1. This study was conducted in one of the colleges in Thailand, specifically the Chulachomklao Royal Military Academy. The study should be repeated in other military academies in an attempt to confirm the findings.

2. The instructional strategy of providing students with behavioral objectives prior to instruction should be investigated using other chemistry topics and other disciplines of science.

3. The effectiveness of behavioral objectives could be investigated when different teaching methodologies are utilized. For example, the effects of behavioral objectives
in an inquiry approach to teaching could be compared to the effects of behavioral objectives in a lecture approach to teaching.

4. A study should be conducted to investigate the effects of providing behavioral objectives on student achievement of psychomotor skills in chemistry.

5. A study should be conducted to investigate why behavioral objective were effective in improving achievement.

6. The present study should be repeated several times to see if the continued use of behavioral objectives would result in similar findings.

7. What is the effect of providing behavioral objectives for the various types of learners? For example, a study needs to be conducted to determine if the use of behavioral objectives are as effective for low ability as high ability students.
BIBLIOGRAPHY


APPENDICES
Appendix A

Checklist for evaluating the reliability and content validity of objectives
CHECKLIST FOR EVALUATING THE RELIABILITY AND CONTENT VALIDITY OF BEHAVIORAL OBJECTIVES:

Checklist--check grid if it applies--may also answer yes or no or comment in the grid.

a. Meaning of objective is not clear.
b. Objective can be interpreted in too many ways.
c. Objective is too technical (t) or too general (g).
d. Need better words to stimulate or initiate the behavior (performance conditions).
e. Need a better action word (verb) to denote behavior to be performed by the student.
f. Optional for objectives--may need an acceptable student performance level.
g. Does it seem that the performance conditions of objective will help aid in obtaining the behavior wanted as indicated by the action verb?
h. The behavior that is expected is not measurable.
i. The acceptable student performance does not relate to or agree with the performance conditions which we were set up.
j. Other objectives which might be added ________________
k. Comments ____________________________________________
Appendix B

Behavioral and non-behavioral objectives for classroom and laboratory instruction

1. Behavioral objectives for classroom instruction on page 154

2. Non-behavioral objectives for classroom instruction on page 159

3. Behavioral objectives for laboratory instruction on page 163

4. Non-behavioral objectives for laboratory instruction on page 165
General chemistry course objectives

Direction:
Attached you will find a set of course objectives for the unit that you are presently studying. You are encouraged to use these objectives to organize knowledge obtained from reading the textbook, lecture, use it in the laboratory while subject matter are presented. You should find them particularly helpful in deciding what is important to know and understand for exams. Do not share the objectives with students in other sections.
BEHAVIORAL OBJECTIVES
Electrochemistry Unit

Redox reaction

1. Define the meaning of the following terms: oxidation, reduction, reducing agent and oxidizing agent.

2. Given the formula of a compound, calculate the oxidation number of the underlined atom correctly.

3. Given the set of chemical equations, identify which chemical equation are redox reactions.

4. Given the unbalanced redox equation, demonstrate the ability to balance the redox equation using half-reaction method or oxidation number method.

Galvanic cell and diagram

5. Given a schematic diagram or figure of a galvanic cell, identify the various parts and write equations for each electrode reaction correctly.

6. Explain the principle and mechanisms involved in galvanic cell.

7. Given the diagram of a galvanic cell, identify electrodes and draw the figure of galvanic cell correctly.

Cell potential and standard reduction potential

8. Demonstrate understanding of the meaning of "standard reduction potential".

9. Given two of the following three quantities, i.e., the standard reduction potential at the anode, that at the cathode, and that of the cell, calculate the third correctly to two significances.

10. Given the necessary standard reduction potentials for the half-reactions occurring in a galvanic cell, decide which direction the electrons flow, which is the anode and which the cathode, and calculate cell potential correctly to two significances.

11. Given the necessary standard reduction potentials, determine whether a chemical reaction is spontaneous.
Cell Potentials and Thermodynamics

12. Given redox equation and standard reduction potential of half-cell, interconvert the cell potential for a reaction with its free energy.

The effect of concentration on cell potentials

13. Write the Nernst equation correctly for a given redox reaction.

14. Given redox reaction and standard reduction potential of half-cell, calculate its equilibrium constant correctly to two significances.

15. Given redox reaction and the concentration of the electrolytes, calculate the cell potential or calculate concentration ratio of electrolytes correctly to two significances.

Electrolysis

16. Explain the principle and mechanisms of electrolysis.

17. Given the name of a molten electrolyte, decide what reaction occurs at the anode, or at the cathode, and what substance occurs there.

18. Given the name of an aqueous of the electrolyte, decide what reaction occurs at the anode, or at the cathode, and what substance occurs there.

Stoichiometric relationships in electrolytes

19. Calculate the number of Faradays needed to convert a given number of moles of a substance or the quantity in mass unit to another form correctly to two significances or vice-versa.

20. Given the current in ampere unit and time need to change the chemical reaction, calculate the quantity of substance transformation correctly to two significances.

21. Given three of the following quantities, i.e., the current, the time, the quantity of substance occur, and the change in oxidation state, calculate the fourth correctly to two significances.
BEHAVIORAL OBJECTIVES

Acid-Base Unit

The ion-product constant of water

1. Write the equation for the self-ionization of a weak acid or weak base.

2. Calculate $[H^+]$ or $[OH^-]$ or $K_w$ for a solution in water correctly to two significances, given the other two.

The pH concept

3. Given a solution with different pH, identify which is more acid or base.

4. Given $[H^+]$ or $[OH^-]$ or concentration of acid or base, calculate pH or pOH correctly to two significances or vice-versa.

5. Given a pH of solution and after it is mixed with acid base, calculate the new pH correctly to two significances.

6. Given $K_w$ and the concentration of a solution of a strong acid or base, calculate the pH, pOH or $[H^+]$, $[OH^-]$ of the solution correctly to two significances.

Acid and base ionization constants

7. Write the equilibrium expression $K_a$ or $K_b$ for an acid or base, given its formula.

8. Write the equilibrium expression for $K_{a1}$, $K_{a2}$ or $K_a$ for a polyprotic acid.

9. Given the values of $K_a$ or $pK_a$ for two acids or $K_b$ or $pK_b$ for two bases, decide which will have the greater acidity or greater pH when in solution, and which is the stronger acid or base.

10. Explain the relationship between the concept of strong and weak acids and bases and the values of $K_a$ and $K_b$.

11. Given a set of $K_a$ of polyprotic acid, select which is stronger.

12. Given $K_a$ or $K_b$ and the concentration of a solution of weak acid or base, calculate the $[H^+]$ or $[OH^-]$ of the solution correctly to two significances.
13. Given $K_a$ or $K_b$, **calculate** $pK_a$ or $pK_b$ correctly to two significances or vice-versa.

14. Given $K_a$ or $pK_a$ for acid and $K_w$ or $pK_w$, **calculate** the value of $K_b$ or $pK_b$ correctly to two significances or vice-versa.

**Buffers**

15. **Select** an appropriate acid to prepare the buffer at any given pH using $K_a$ of each acid as the criteria.

16. Given an initial pH of solutions and their pH change when they are mixed with acid or base, **identify** which is a buffer.

17. Given the buffer system, **supply** a correct explanation of how a buffer works when acid or base is added to a buffer system.

18. Given two of the following three quantities, i.e., the concentration or mole of salt and acid, pH or pOH, and $K_a$ or $K_b$, **calculate** the third correctly to two significances.

19. Given $K_a$ or $pK_a$ and the concentration or mole of acid and salt of acid, **calculate** the pH before and after addition of known concentration of acid or base or **calculate** the concentration of acid or base when the initial and final pH are given correctly to two significances.

**Hydrolysis of salt**

20. Given two of the following three quantities, i.e., the concentration of salt, pH or pOH, and $K_h$, **calculate** the third correctly to two significances.

21. Given the name or formula of salt, **predict** whether its solution in water will be acidic, neutral, or basic.

22. **Demonstrate** understanding of the meaning of hydrolysis.
Titration

23. Given the titration data, identify the corresponding titration curve.

24. Given a pair of acid and base, and the pH range of indicator, select an appropriate indicator for titration or vice-versa.

25. Given the following, the volume and concentration of acidic and basic solution and $K_a$ or $K_b$, calculate the pH of titrated solution correctly to two significances.
NON-BEHAVIORAL OBJECTIVES

Electrochemistry Unit

Redox reaction

1. Understand the following terms: oxidation, reduction, reducing agent and oxidizing agent.

2. Understand the oxidation number.

3. Understand redox reaction.

4. Understand how to balance the redox equation.

Galvanic cell and diagram

5. Understand galvanic cell or electrolytic cell.

6. Know how a galvanic cell works.

7. Know the composition of galvanic cell.

Cell potential and standard reduction potential

8. Understand the following term: "standard reduction potential".

9. Understand the standard reduction potential of cell.

10. Understand the direction of electrons flow in a galvanic cell.

11. Understand the spontaneous reaction.

Cell Potentials and Thermodynamics

12. Understand the relationship between standard reduction potential of cell and its free energy.

The effect of concentration on cell potentials

13. Understand the Nernst equation.

14. Understand the relationship between the standard reduction potential and its equilibrium constant.
15. **Understand** the relationship between the concentration of the electrolytes and cell potential.

**Electrolysis**

16. **Understand** electrolysis.

17. **Understand** the electrolysis of molten electrolyte.

18. **Understand** the electrolysis of an aqueous of the electrolyte.

**Stoichiometric relationships in electrolytes**

19. **Know** Faraday's principle.

20. **Understand** the relationship among the current, time needed to change the chemical reaction and the quantity of substance transformed.

21. **Understand** the relationship among the current, time needed to change the chemical reaction, the quantity of substances occurring, and the change in oxidation state.
NON-BEHAVIORAL OBJECTIVES

Acid-Base Unit

The ion-product constant of water

1. Understand the self-ionization of weak acid or weak base.

2. Understand the relationships between $[H^+]$ and $[OH^-]$.

The pH concept

3. Understand the different types of solutions.

4. Understand pH and the value of pH.

5. Understand pOH and the value of pOH.

6. Understand the relationship between $K_w$, $[H^+]$, and $[OH^-]$ of the solution.

Acid and base ionization constants

7. Understand the equilibrium constant, $K_a$ or $K_b$ for an acid or base.

8. Understand the equilibrium constants for a polyprotic acid.

9. Understand the strength of acid or base.

10. Understand the relationship between the values of $K_a$ and $K_b$.

11. Understand the values of $K_a$ of polyprotic acid are different.

12. Understand the relationship between $K_a$ or $K_b$ and $[H^+]$ or $[OH^-]$ of acid or basic solution.

13. Understand the relationship between $K_a$ or $K_b$ and $pK_a$ or $pK_b$.

14. Understand the relationship of $K_a$ or $pK_a$, $K_w$ or $pK_w$, and $K_b$ or $pK_b$. 
Buffer

15. **Understand** buffer systems.
16. **Know** the composition of buffer solutions.
17. **Understand** how buffer works.
18. **Understand** the relationship among the concentration or mole of salt and acid, pH or pOH, and $K_a$ or $K_b$.
19. **Understand** how to use buffer solutions.

Hydrolysis of salt

20. **Understand** $K_h$ values.
21. **Understand** the hydrolysis of salt.
22. **Know** the meaning of hydrolysis.

Titration

23. **Understand** the titration process.
24. **Know** how to use indicators for titration.
25. **Understand** the relationship between $K_a$ or $K_b$ and pH in titration.
BEHAVIORAL OBJECTIVES

Electroplating lead

1. **Define** the meanings of the following terms: electroplating and electrolysis.

2. **Explain** the principle and mechanism of electroplating.

3. **Explain** or **decide** which factors affect electroplating.

4. **Calculate** the number of moles of electrons passing through the circuit in electroplating process correctly to two significances, given time and current in ampere unit.

5. Given type of metal needed to be plated, **select** an appropriate electrolyte and **set up** the equipment correctly.

6. **Identify** safety procedures whenever working with electroplating.

7. Given each of the systematic "errors" **state** whether the error will cause results and **give** the reasoning in each case.
BEHAVIORAL OBJECTIVES

Acid-base titration

1. Define the meaning of the following terms: standard solution, titration, equivalence point, indicator, and end point.

2. Given the titration data, draw the titration curve.

3. Given the titration data or titration curve of weak acid and strong base or strong acid and weak base, calculate $K_a$ or $K_b$ and concentration of unknown correctly to two and three significances respectively.

4. Identify safety procedures whenever working with acid and base.

5. Select equipment and reagents to perform the titration.

6. Read a buret to the nearest hundredth of a ml.

7. Identify and order the steps in doing a titration.

8. Given each of the systematic "errors", state whether the error will cause results to be high or low and give the reasoning in each case.

9. Demonstrate the ability to record the experimental data onto the provided data sheet.
NON-BEHAVIORAL OBJECTIVES

Electroplating lead

1. **Understand** the following words: electroplating and electrolysis.

2. **Understand** the electroplating lead process in this experiment.

3. **Know** the factors which affect to electroplating.

4. **Understand** the relationship between current and the number of mole of electron.

5. **Understand** the electroplating process for other metals.

6. **Know** the proper safety procedures.

7. **Understand** the electroplating systematic errors.

NON-BEHAVIORAL OBJECTIVES

Acid-base titration

1. **Understand** the following words: standard solution, titration, equivalence point, indicator, and end point.

2. **Know** the titration techniques.

3. **Understand** the relationship between the titration curve and $K_a$ or $K_b$.

4. **Know** safety procedures whenever working with acid and base.

5. **Know** about equipment and chemical reagents for titration.

6. **Know** how to use a buret.

7. **Understand** the procedure of titration.

8. **Understand** titration systematic errors.

9. **Know** about titration data.
Appendix C

Relationship of test items to behavioral objectives
Class examination

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Laboratory examination

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Appendix D

Table of specification
# TABLE OF SPECIFICATION

**Electrochemistry unit**

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## Acid-base unit

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<td>5</td>
<td>12</td>
<td>18</td>
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Appendix E

Test items

1. Classroom examination on page 172
2. Laboratory examination on page 181
CLASSROOM EXAMINATION

Directions. Unless indicated otherwise, this is a multiple choice test. All questions have only one correct answer. In each question, circle the letter you choose.

1. Consider the reaction

\[ 2\text{Fe}^3+(aq) + 2\text{I}^-(aq) \rightarrow 2\text{Fe}^{2+}(aq) + \text{I}_2(aq) \]

Which statement is true for the reaction?

a. \(\text{Fe}^3+\) is oxidized.
b. \(\text{Fe}^3+\) increases in oxidation number.
c. \(\text{Fe}^3+\) is reduced.
d. \(\text{I}^-\) is reduced.

2. Identify the pair of compounds having underlined atoms with the same oxidation number.

a. \(\text{H}_2\text{SO}_4\) and \(\text{HMnO}_4\)
b. \(\text{HClO}_4\) and \(\text{H}_2\text{Cr}_2\text{O}_7\)
c. \(\text{HClO}_3\) and \(\text{HNO}_2\)
d. \(\text{HNO}_3\) and \(\text{H}_3\text{PO}_4\)

3. When the half-equation

\[ \text{MnO}_4^- + \text{H}^+ + \text{n} \text{e}^- \rightarrow \text{Mn}^{2+} + \text{H}_2\text{O} \]

is balanced, the value of \(\text{n}\) is

a. 5  b. 2  c. 7  d. 8

4. When the equation

\[ \text{Zn} + \text{H}^+ + \text{H}_3\text{AsO}_4 \rightarrow \text{AsH}_3 + \text{H}_2\text{O} + \text{Zn}^{2+} \]

is balanced, the number of moles of water is

a. 2  b. 4  c. 6  d. 8
5. This question is based on the cell shown in the illustration.

![Electrode diagram](image)

Which is true?

a. Oxidation is taking place at nickel electrode.
b. The nickel electrode gains in mass.
c. One mole of electron converts one-third mole of aluminum ion to metallic aluminum.
d. In the salt bridge, the negative ion move from the aluminum half-cell into the nickel half-cell.

6. Consider the diagram Mn/Mn$^{2+}$//Co$^{3+}$,Co$^{2+}$/Pt. Which is true?

a. Mn acts as the cathode and Pt acts as anode.
b. Co$^{2+}$ is oxidizing agent.
c. Mn + 2Co$^{3+}$ -----> Mn$^{2+}$ + 2Co$^{2+}$
d. Mn is positive electrode and Pt is negative electrode.
7. The potential between two electrodes is the "standard cell potential" for the reaction

\[ A + B \rightarrow A^+ + B^- \]

when

a. the electrodes are made of A and B and A is immersed in 1.0 M A\(^+\) and B in 1.0 M B\(^-\).

b. the electrodes are inert and are both immersed in a single solution containing 1.0 M A and 1.0 M B.

c. one electrode is made of A and is immersed in 1.0 M B\(^-\) and the other is made of B and immersed in 1.0 M A\(^+\).

d. both electrodes are inert, one is immersed in a solution containing 1.0 M A and 1.0 M B\(^-\), and the other in a solution containing 1.0 M A\(^+\) and 1.0 M B.

8. Which of the following reactions is a redox reaction?

a. \(2\text{CCl}_4 + K_2\text{CrO}_4 \rightarrow 2\text{CCl}_2 + \text{CrO}_2\text{Cl}_2 + 2\text{KCl}\)

b. \(K_2\text{CrO}_4 + 2\text{HCl} \rightarrow K_2\text{Cr}_2\text{O}_7 + 2\text{KCl} + \text{H}_2\text{O}\)

c. \(\text{CaCO}_3 + 2\text{H}^+ \rightarrow \text{Ca}^{2+} + \text{H}_2\text{O} + \text{CO}_2\)

d. \(\text{Zn} + \text{Pb(NO}_3)_2 \rightarrow \text{Zn(NO}_3)_2 + \text{Pb}\)

9. The following half-reactions have the reduction potentials shown:

\[ \text{Au}^{3+} + 3\text{e}^- \rightarrow \text{Au} \quad E^\circ = +1.42 \text{ V} \]

\[ \text{Br}_2 + 2\text{e}^- \rightarrow 2\text{Br}^- \quad E^\circ = +1.07 \text{ V} \]

What is the potential for the reaction

\[ 3\text{Br}_2 + 2\text{Au} \rightarrow 6\text{Br}^- + 2\text{Au}^{3+} \]

a. -0.35 V  b. -0.37 V  c. +0.70 V  d. +2.49 V
10. In a cell in which a silver electrode is immersed in 1.0 M silver nitrate and a copper electrode in a 1.0 M copper nitrate and the silver electrode is connected to the positive terminal of the voltmeter. The half-cell reduction potentials are

$$\text{Ag}^+ + e^- \rightarrow \text{Ag} ; \quad E^0 = +0.80 \text{ V}$$
$$\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} ; \quad E^0 = +0.34 \text{ V}$$

Which is true?

a. The reading on the voltmeter is +1.14 V.

b. Electrons flow from the silver electrode to the copper electrode.

c. The silver electrode is the cathode.

d. Electrons flow from copper to the copper nitrate.

11. The following half-reactions have the reduction potentials shown

$$\text{MnO}_4^- + 8H^+ + 5e^- \rightarrow \text{Mn}^{2+} + 4H_2O \quad E^0 = +1.49 \text{ V}$$
$$\text{Br}_2 + 2e^- \rightarrow 2\text{Br}^- \quad E^0 = +1.07 \text{ V}$$
$$\text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+} \quad E^0 = +0.77 \text{ V}$$

Which of the following reactions is spontaneous?

a. $2\text{Fe}^{3+} + 2\text{Br}^- \rightarrow 2\text{Fe}^{2+} + \text{Br}_2$

b. $5\text{Fe}^{3+} + \text{Mn}^{2+} + 4H_2O \rightarrow 5\text{Fe}^{2+} + \text{MnO}_4^- + 8H^+$

c. $\text{Br}_2 + 2\text{Fe}^{2+} \rightarrow 2\text{Br}^- + 2\text{Fe}^{3+}$

d. $5\text{Br}_2 + 2\text{Mn}^{2+} + 8H_2O \rightarrow 10\text{Br}^- + 2\text{MnO}_4^- + 16H^+$

12. Pt(s)/Sn^{2+}(1M),Sn^{4+}(1M)//Cu^{2+}(1M)/Cu(s) \quad E_{cell} = 0.164 \text{ V}.

What would be the $G$ value for this cell?

a. -15823.868 joule       

b. -31647.736 joule

c. 17753.608 joule       

d. 35507.216 joule
13. The following standard reduction potential
\[ \text{Zn}^{2+} + 2e^- \longrightarrow \text{Zn} \quad E^\circ = -0.76 \text{ V} \]
\[ \text{Cu}^{2+} + 2e^- \longrightarrow \text{Cu} \quad E^\circ = +0.34 \text{ V} \]

What would be the E value of the cell at 25 °C of the following equation?
\[ \text{Zn}(s) + \text{Cu}^{2+}(0.04\text{M}) \longrightarrow \text{Cu}(s) + \text{Zn}^{2+}(0.40\text{M}) \]

a. +0.45 volt  
b. +1.07 volt  
c. +1.10 volt  
d. +1.13 volt

14. When molten potassium iodide is electrolyzed, which is true?
   a. Molten potassium metal is formed at anode
   b. K \[ \longrightarrow \] K\(^+\) + e\(^-\)
   c. Iodide is reduced to iodine.
   d. I\(_2\) forms at the anode.

15. How many Faradays are required to convert 17.4 moles of Fe\(^{3+}\) to Fe\(^{2+}\)?
   a. 2.9  
b. 17.4  
c. 34.8  
d. 65.6

16. In a cold fusion reactor, 0.80 amps is passed through a solution of H\(_2\)O for 12 hours. What mass of hydrogen molecule should theoretically be produced? (Atomic weight of hydrogen= 1.007)
   a. 0.18 g  
b. 0.36 g  
c. 0.72 g  
d. 1.01 g

17. Chromium metal can be plated from an acidic solution of CrO\(_3\),
\[ \text{CrO}_3(aq) + 6\text{H}^+(aq) + 6e^- \longrightarrow \text{Cr}(s) + 3\text{H}_2\text{O} \]

How many grams of chromium will be plated by the passage of 19,300 coulombs? (Cr= 51.996)
   a. 10.40  
b. 5.19  
c. 1.73  
d. 0.20
18. The dissociation constant for a weak base BOH in water was found to be $1.25 \times 10^{-6}$. What is the concentration of $H^+$ in a 3.2 M solution of BOH?
   a. $2.0 \times 10^{-3}$ M
   b. $4.0 \times 10^{-6}$ M
   c. $1.6 \times 10^{-11}$ M
   d. $5.0 \times 10^{-12}$ M

19. If $K_w$ in a specimen of seawater is $3.98 \times 10^{-13}$ and the concentration of $H^+$ is $3.2 \times 10^{-5}$, what is the concentration of $OH^-$?
   a. $3.2 \times 10^{-5}$
   b. $6.3 \times 10^{-7}$
   c. $1.2 \times 10^{-8}$
   d. $3.1 \times 10^{-18}$

20. The pH of a 0.03 M HCl solution is
   a. 1.5  b. 2.5  c. 3.5  d. 12.5

21. If a solution has pH=n and enough base is added to reduce the concentration of $H^+$ by a factor of 100, what is the new pH?
   a. n-100  b. n/100  c. n+2  d. n-2

22. What is the pH of 0.0079 M KOH if $K_w = 3.91 \times 10^{-12}$?
   a. 2.1  b. 6.9  c. 9.3  d. 11.3

23. What is the definition of $K_a$ for HOAc?
   a. $[H^+][OAc^-]/[HOAc]$
   b. $[H_2OAc^+][OH^-]/[HOAc]$
   c. $[HOAc]/[H^+][OAc^-]$
   d. $[HOAc][OH^-]/[HOAc]$
24. pK_a for 0.1 M nitrous acid is 3.1, and pK_a for 0.1 M acetic acid is 4.7. Which is true?

a. Nitrous acid is a stronger acid than acetic acid, and its solutions have higher pH.
b. Nitrous acid is a stronger acid than acetic acid, and its solutions have lower pH.
c. The nitrite ion is a stronger base than the acetate ion and its sodium salt solutions have higher pH.
d. The nitrite ion is a weaker base than the acetate ion and its sodium salt solutions have higher pH.

25. pK_a for the ammonium ion at 50 °C is 4.79. What is pK_b for ammonia? pK_w at 50 °C is 13.26.

a. 8.47  b. 9.21  c. 18.05  d. 18.79

26. A buffer of pH 4.1 is to be prepared from a weak acid and its salt. The best acid from which to prepare the buffer is

a. phthalic acid, K_1 = 1.3 \times 10^{-3}
b. hydrogen phthalate, K_2 = 3.9 \times 10^{-5}
c. benzoic acid, K = 6.3 \times 10^{-5}
d. hydrocyanic acid, K = 4 \times 10^{-10}

27. Which buffer would be better able to hold a steady pH range 5-6 with additions of 0.01 mole of acid or base.

a. 0.1 M NH_4Cl and 1.0 M NH_3
b. 1.0 M NH_4Cl and 0.1 M NH_4OH
c. 1.0 M CH_3COONa and 1.0 M CH_3COOH
d. 1.0 M NaOH and 1.0 M CH_3COOH
28. When a little KOH is added to a buffer made from acetic acid HAc and sodium acetate NaOAc, which of the following best describes the reaction of the buffer?

a. \( \text{NaOAc} + \text{OH}^- \rightarrow \text{NaOH} + \text{OAc}^- \)
b. \( \text{HOAc} + \text{OH}^- \rightarrow \text{H}_2\text{O} + \text{OAc}^- \)
c. \( \text{OAc}^- + \text{H}_2\text{O} \rightarrow \text{HOAc} + \text{OH}^- \)
d. \( \text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O} \)

29. What is the pH of a solution containing 0.04 M \( \text{Na}_2\text{SO}_3 \) and 0.03 M \( \text{NaHSO}_3 \)?

\( K_1 \) for \( \text{H}_2\text{SO}_3 \) is 1.5 x 10\(^{-2}\) and \( K_2 \) is 1.2 x 10\(^{-7}\)

a. 1.5  b. 2.1  c. 6.6  d. 6.9

30. A solution contains 0.10 M \( \text{CH}_3\text{COONa} \) and 0.10 M \( \text{CH}_3\text{COOH} \). If 0.05 mole of NaOH is added. What is the final pH of this solution? (\( \text{CH}_3\text{COOH} \), \( K_a = 1.8 \times 10^{-5} \))

a. 4.32  b. 4.62  c. 4.80  d. 4.98

31. For \( \text{H}_3\text{PO}_4 \) \( K_a1 = 7 \times 10^{-3}, K_a2 = 6 \times 10^{-8}, K_a3 = 4 \times 10^{-13} \)

For \( \text{H}_3\text{Cl}_i \) \( K_a1 = 7 \times 10^{-4}, K_a2 = 2 \times 10^{-5}, K_a3 = 6 \times 10^{-6} \)

Which of the following is true?

a. \( \text{H}_2\text{Cl}^- \) is a stronger acid than \( \text{H}_3\text{PO}_4^- \)
b. \( \text{H}_2\text{PO}_4^- \) is a stronger acid than \( \text{H}_2\text{Cl}^- \)
c. \( \text{HCl}_2^- \) is a stronger acid than \( \text{H}_2\text{PO}_4^- \)
d. \( \text{H}_3\text{Cl} \) is a stronger acid than \( \text{H}_3\text{PO}_4^- \)
32. For which titration does methyl red (pH range 3.1-4.2) perform most satisfactory?

   a. HClO₄ with KOH
   b. HF with KOH
   c. CH₃COOH with NaOH
   d. HCl with NH₄OH

33. Which is true?

   a. 0.1 M AlCl₃ has pH ≈ 7 and 0.1 M NH₄Cl has pH < 7
   b. 0.1 M NaCN has pH ≈ 7 and 0.1 M Na₃PO₄ has pH > 7
   c. 0.1 M NH₄Cl has pH < 7 and 0.1 M NaNO₃ has pH ≈ 7
   d. 0.1 M NH₄Cl has pH ≈ 7 and 0.1 M Fe(NO₃)₃ has pH > 7

34. Which equation best represents the hydrolysis of a salt?

   a. SO₃²⁻ + H⁺ --------> HSO₃⁻
   b. Mg²⁺ + OH⁻ --------> MgOH⁺
   c. HCl + H₂O --------> H₃O⁺ + Cl⁻
   d. HAsO₃²⁻ + H₂O --------> H₂AsO₃⁻ + OH⁻

35. Fifty ml. of 0.10 M HCOOH is titrated with 0.01 M NaOH. What is the pH at the equivalence point.

   HCOOH \(K_a = 1.8 \times 10^{-4}\), \(K_w = 1 \times 10^{-14}\)

   a. 7.00  b. 8.23  c. 9.77  d. 10.48
LABORATORY EXAM

Directions. Unless indicated otherwise, this is a multiple choice test. All questions have only one correct answer. In each question, circle the letter you choose.

For questions 1 and 2, the following information applies.

A sample of a solution of an unknown acid, HA, is measured into a beaker using a 25 ml transfer pipet. Fifty ml of water is added to the beaker and the mixture titrated with 0.09876 M NaOH. The equivalence point occurs when 30.14 ml of NaOH has been added. The pH at the half equivalence point is found to be 4.30.

1. What is the concentration of the unknown acid present in the original sample?
   a. 0.059 M
   b. 0.081 M
   c. 0.118 M
   d. 0.162 M

2. What is the $K_a$ of unknown acid?
   a. $1.99 \times 10^{-4}$
   b. $4.30 \times 10^{-5}$
   c. $5.01 \times 10^{-5}$
   d. $3.98 \times 10^{-8}$

3. Which of the following is true about a titration end point?
   a. One mole of $H_3O^+$ reacted = one mole of $OH^-$ reacted.
   b. pH changes rapidly near the end point.
   c. Indicator color changes slowly near the end point.
   d. One mole of $H_2O$ is formed for one-half mole of $OH^-$ titrated.
4. You have 20.00 ml of HCOOH solution and you have to find its concentration. From the list that follows, select the appropriate equipment you would use to do the titration.

   a. 10 ml transfer pipet
   b. 15 ml buret
   c. 15 ml graduate cylinder
   d. 15 ml beaker

5. The unknown HCOOH in question 4 is about 0.05 M. From the list that follows, select the reagents you need to do the titration.

   a. Distilled water, methyl orange (pH range 3.2-4.4), and 0.10 M NH₄OH.
   b. Distilled water, ethyl red (pH range 4.0-5.8), and 0.01 M NaOH.
   c. Distilled water, phenolphthalein (pH range 8.2-10.0), and 0.10 M NaOH.
   d. Distilled water, clayton yellow (pH range 12.2-13.2), and 0.05 M NH₄OH.

6. What the correct reading for the buret ?

   a. 32.20 ml
   b. 32.26 ml
   c. 33.70 ml
   d. 33.74 ml
For questions 7 to 9, the following information applies.

When Cadet Sam performs titration experiment between 0.1 M NaOH and a sample of a solution of an unknown acid, he makes each of the systematic "errors" below. For each error, state whether the error will cause Sam's results for concentration of the unknown acid to be high, low, or unaffected compared to the true value of unknown acid. Give your reason in each case.

7. By using a 10 ml transfer pipet in measuring out his samples of unknown acid solution, liberating Cadet Sam does his own thing--each time he pipets a sample, he blows the small amount of residual solution out of the pipet in with the rest of the sample.
   a. To be high, because the volume of base used is greater than the true volume.
   b. To be high, because the volume of acid is greater than 10 ml.
   c. To be low, because the volume of base used is less than the true volume.
   d. To be unaffected, because the volume of acid is exactly 10 ml.

8. Absentminded Cadet Sam forgets and adds 4 drops of phenolphthalein indicator instead of 2 drops to the unknown acid solution in the Erlenmeyer flask.
   a. To be high, because the volume of base used is greater than the true volume.
   b. To be high, because indicator color changes slower in 4 drops than 2 drops solution.
   c. To be unaffected, because indicator is not involved in neutralization.
   d. To be low, because indicator color changes faster in 4 drops than in 2 drops of solution.
9. The usually fastidious Sam uses a dirty buret, so that drops of NaOH form along the inside walls of the buret during each titration.

   a. To be high, because the volume of base used is greater than true volume.

   b. To be low, because some contaminated substance can react with unknown acid.

   c. To be low, because the volume of base used is less than true volume.

   d. To be high, because the concentration of base increases.

10. Which of the following curves show titration between 50 ml of 0.1 M NH₄OH and 50 ml 0.05 M H₂SO₄ (Given pKₐ = 4.75)

   a. 

   b. 

   c. 

   d.
11. What is electroplating?

a. Metal purification process in which the metal anode dissolves into solution.

b. An electrolysis process in which metal ion deposits on cathode.

c. The process which has the functional principle the same as galvanic cell but the chemical reaction at anode is reduction.

d. The process which has the same principle as electrolysis, except that the cathode dissolves into solution.

12. Which of the following is true about electroplating?

a. In electroplating we can use either alternating current or direct current.

b. The metal needed to be plated acts as the anode.

c. Oxidation takes place at the plated electrode.

d. The voltage must be higher than the combined emf. of both electrodes.

13. Which of the following is true about the factors that can affect electroplating.

a. If we make the surface of metal to be plated cleaner and smoother, the electroplating rate will be decreased.

b. If we increase the concentration of electrolyte, the electroplating rate will be increased and the surface of plated metal becomes smoother.

c. If we increase the voltage of current, the rate of electroplating will increase.

d. If the ratio of current to surface area of metal increases, the rate of electroplating will decrease.
14. How many moles of electrons pass through the circuit, when the supply is 0.30 amp. of current in 15 min.

a. \(1.685 \times 10^{20}\) mole
b. \(2.80 \times 10^{-3}\) mole
c. 4.5 mole
d. \(2.70 \times 10^2\) mole

15. In an electroplating process, Ag needs to be plated onto iron spoon. Which of the following is true?

a. Ag acts as the cathode and iron spoon acts as the anode.

b. The electrolyte must be a solution of silver salt, but Pt can be used as the anode.

c. The amount of Ag deposited on the iron spoon correlates with gram-equivalent of Ag and amperes.

d. If we use Pt as anode, the number of anions in the electrolyte will be less than cation.

For questions 16 to 17, the following information applies.

A student electroplates a silver spoon with gold by using \(\text{Au(CN)}_2^-\) solution. He does not follow the laboratory instruction at every steps.

16. He needs to increase the electroplating rate by double the concentration of \(\text{Au(CN)}_2^-\). Which of the following is true?

a. The electroplating rate will be double because the solution contains two mole of \(\text{Au}^+\).

b. When the current and time are still constant, the amount of Au deposit on silver spoon will be doubled.

c. The electroplating rate is not changed because the rate does not depend on the concentration of electrolyte.

d. The amount of Au deposited on a silver spoon is constant whenever the current and time are constant.
17. He polishes a silver spoon with sandpaper. The silver spoon surface become clean but it is not completely smooth. Which the following is true?

a. After the electroplating is finished, the silver spoon surface become completely smooth.

b. Because of the roughness of silver spoon texture, Au deposits pretty well on the silver spoon but the texture is still rough.

c. The electroplating rate does not depend on the roughness or smoothness of electroplated metal texture; the rate depends on current and time.

d. The amount of Au deposited on the rough silver spoon surface will be greater than on the smooth surface.
Appendix F

Student questionnaires
QUESTIONNAIRE ITEMS
Given to student after test

Name ___________________________   Section ________

Direction: Put the x into [ ] answer you selected.

1. Did you use the objectives to study for the test?
   [ ] yes   [ ] no

2. Did the objectives help you decide what to study for the test?
   [ ] yes   [ ] no

3. Did the objectives help make your study time more efficient?
   [ ] yes   [ ] no

4. Did you share the objectives with students in other section?
   [ ] yes   [ ] no

   If the answer to the above question is yes, with how many students in which sections did you share the objectives? ________________

5. Do you need the objectives for next unit?
   [ ] yes   [ ] no

6. Comments
   ____________________________________________