AN APPROACH TO THE TEACHING OF IN-
TRODUCTORY PHYSICS IN A LARGE-
GROUP, NON-LABORATORY SETTING

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CHAPTER I

INTRODUCTION

Physics in recent years has experienced a decrease in enrollment (14) and a loss of some of the prestige that should be associated with a science most basic to the study of man. Ernest C. Pollard (32) alludes to the growing alienation between science and society and suggests that many of the students are in physics classes only because, in some way, Deans and others in curriculum planning groups feel that a physics requirement is commensurate with a liberal education. The physics profession must surely share the blame for not having created courses viewed by students and other members of the academic and nonacademic community as relevant to college education.

Background for the Study

This study had as its goal the development of an approach to the teaching of introductory physics, for the student who is a nonphysics major and in most cases a nonscience major.

In the introduction to "The Proceedings of the Boulder Conference on Physics for Nonscience Majors," (10). It was pointed out that introductory courses tended to go to one of two extremes. First were the courses in which the instructors insist that the topics and techniques which prove suitable for science majors are the best for the entire student body, and arguing that if some individuals were not prepared mathematically and psychologically for the rigors of the course, that this was the student's problem. At the other extreme are many physicists who feel that it is unrealistic to expect nonscience majors to cope with the basic concepts of physics, and offer them a diluted science survey instead. Neither approach appears suitable for the nonscience student.

A compromise between these two extremes is assuredly called for. Perhaps even more than a compromise is available if, in attempting to solve the problem of better physics teaching and learning, one brings into play information on teaching and learning garnered by researchers in educational psychology.

The study of physics involves many basic concepts which are readily introduced, studied, and confirmed through observation and manipulation of objects and systems, as well as through reading and lecture presentation. These basic ideas do not have to be approached at a highly sophisticated mathematical level nor in a watered down fashion if pace and teaching format are matched to the student's capacity for learning. Jerome Bruner (6) in The Process of Education, represents the problem as two-fold: First, how to have the basic subjects rewritten and their teaching materials revamped in such a way that the pervading and powerful ideas and attitudes contained therein are given a central role; second, how to match the levels of the materials to the capacities of students of different abilities at different grades in school.

In the 1963 Report of the Commission on College Physics (9), the suggestion is made that one must proceed in teaching as he does in experimental physics; measuring instruments must be developed collaterally with the study of the learning process. This necessitates cooperation between the physical scientists and educational psychologists.

In this study a cybernetic model of The Behaving and Learning Cycle developed by Asahel D. Woodruff (40) an educational psychologist, will be used to describe the learning process within the student. This also specifies the conditions to be met by a model of instruction which in turn will be used in one section of an introductory physics course.

Conceptual Physics (2) was selected as a textbook for Descriptive Physics because it was a new text designed for a one semester course in introductory physics. Too, it had as one of its stated aims the presentation of physics principles on a conceptual rather than a mathematical level. This is consistent with Bruner's suggestion that the material match the capacity of the student, which in introductory physics does not include mathematical sophistication.

Statement of the Problem

The major goal was to develop an approach to the teaching of introductory physics based on a cybernetic model of The Behaving and Learning Cycle. To determine its effectiveness it will be necessary to measure the influence of this approach on the student's gain in knowledge (cognitive effect), his final attitudes toward the course (affective response), and to determine any relationship between his educational background and his success in the course.

Significance of the Study

E. Leonard Jossem (26), Chairman of the Commission on College Physics, in the 1968 report of the Commission, suggested during a discussion of curriculum change and improvement, that apparently successful answers to curriculum problems were often localized and temporary in their applications, and that each new generation seemed to require new answers in its own terms. He stated, "We suffer from having no coherent theory of instruction to invoke, and as a result in all too many cases we do not know whether what we are doing is effective."

John Fowler (20), Director of the Commission on College Physics, in an address given at a national conference urged that:

> We approach our teaching as we do a research problem. In research, if our investigations are experimental, they are based on existing theory, or if theoretical, on existing data. We decide on an objective, and usually try for an easily measured yes-no effect; there is polarization or there is none; there is a resonance or there is not one. We make estimates of the size of the effect we are looking for and choose our techniques accordingly. We try to isolate the effects we are looking for and change conditions to average out other possible contributions. We require the latest and best in methods and instrumentation, we worry over precision, estimate our errors and state the uncertainty in our results. We try each step of the way to know what we want to do and to determine whether we are doing it.
>
> Teaching and instruction in physics is admittedly more complex and less easy to quantify than research. But it is as much a part of our profession. And we should approach it as physicists.

The current study was based on a theoretical model of a Behaving and Learning Cycle and the constraints this offers when developing a model for teaching behavior. Such models can furnish a source of hypotheses, through which relevant data can be ordered, and which can be subjected to empirical test.

A study of this type may offer a modest beginning in the attempt to apply research methods which have been successful in physics, to problems associated with physics teaching. It may shed light on better approaches to teaching introductory physics in a large-lecture non-laboratory setting and should be of value to the institutions involved. Finally, data acquired from the first trial of the model may provide information for refinement or change in the model, and thus allow continued testing of the approach.

Limitations of the Study

This study was carried out during a one semester time period and limited to students in Descriptive Physics 1014 at Oklahoma State University. Both experimental and control sections exhibited somewhat lower enrollments than previous semesters thus reducing the size of the sample. Further, since different instructors were in charge of the two sections, the possibility of instructor bias exists.

Clarification of Terms

Student

Members of the Oklahoma State University student body enrolled in Descriptive Physics 1014 during the Spring semester of the 1969-1970 term, are the students.

Knowledge

Knowledge is evidenced by an acquaintance, familiarity and understanding of the laws, relationships, and information associated with physics. In the case of this study, knowledge, in measured form, would be limited to the recognition of physics information, laws and relationships as determined by the pre-test and post-test questions on the examination administered to both sections of the Descriptive Physics course.

Cognition

The process of knowing or perceiving is cognition.

Cognitive Process

The process involved in the act of gaining knowledge, is the cognitive process.

Attitude

Attitudes are feelings or opinions rather than knowledge, and in this study were gauged by responses made to questions or comments given the students in an attitude questionnaire administered at the end of the semester.

Affective Domain

The affective domain relates to feelings and emotions. This is related to and essentially synonymous with attitude as it is used in this study.

Favorable Response

Each statement on the Attitude Measure (see Appendix) was listed as either positive or negative with respect to the goals of the course. A favorable response was one that had a score greater than three on a positive question or one which had a score less than three on a negative question or statement.

Unfavorable Response

A response to a positive statement on the Attitude Measure of less than three was considered an unfavorable response. Likewise a response of greater than three on a negative statement would indicate an unfavorable response with respect to the goals of the course.

Cybernetic System

Cybernetics is a science that compares complex electronic calculators with the human nervous system. In this study the Behaving and Learning Cycle is treated as a group of interacting systems analogous to an electronic system.

Feedback

In an electronic system feedback is the return of information to elements earlier in the chain of sub-systems for modification of the on going operation. In an ideal learning situation feedback from the students continually influences the teaching process, both feedback to the teacher and to the student.

Referential Input

Information gained directly from the environment, frequently non-verbal, is considered referential input.

Percept

A recognizable sensation or impression received by the mind through the senses is a percept. These are the predecessors of concepts.

Perceptual Meaning

Meanings gained through the senses as opposed to verbal transmission of symbols and ideas are perceptual meanings.

Concepts

An idea or generalization formed via the process of perceptual observation and verbal communication is a concept.

Referents

The objects referred to by words or phrases rather than the words or phrases themselves, are referents.

LD Group

The students in the section taught through lectures and demonstrations but with little expectation of active student response, constitute the LD (Lecture, Demonstration) Group.

PDI Group

Students in the experimental section in which presentation and demonstration were both carried out in such a manner that questions would be raised and answers sought from the students, constitute the PDI (Presentation, Discussion, Interaction) Group.

Attitude Measure

This term refers to a questionnaire prepared by the researcher to ascertain the attitude of the students toward the course. This was administered at the end of the semester to both groups.

Outside Help

This term refers to an invitation extended to all students to visit with one of the instructors about reading materials, problem work, or other difficulties experienced in Descriptive Physics.

Basic Assumptions

This study assumes that a pre-test post-test examination constitutes an adequate measure of knowledge gained by the student during the semester.

It also assumes that the attitude of each student toward the course may be measured by the use of a set of statements about the course; some of which should elicit common responses since they are not related to the approach used, while others should elicit differing responses depending upon the teaching approach.

The study assumes that either approach (LD, or PDI) can be applied consistently during the entire semester.

CHAPTER II

REVIEW OF SELECTED LITERATURE

Introduction

John Fowler (20) in speaking of evaluation of professional courses in physics, observes that "We evaluate it, and we try to improve it almost totally in terms of content." This study involved content but the approach to providing content in physics was based on information on the teaching-learning process available from psychology.

The two sections of the review of selected literature will deal first with the teaching-learning process and then course development in physics.

Teaching and Learning

The educational psychology viewpoint on teaching and learning is represented by the work of such men as Jerome S. Bruner, Carl R. Rogers, Asahel D. Woodruff, and Robert M. Gagne.

Carl R. Rogers (35) describes learning that is experimental, meaningful, or significant in terms of the following elements:

(1) It has a quality of personal involvement (feelings as well as cognitive aspects).

(2) It is self-initiated. Even when the impetus comes from without the will to carry through comes from within.

(3) It is pervasive. It makes a difference in the behavior, attitudes and perhaps even the personality of the learner.

(4) It is evaluated by the learner. He can say to himself "it isn't quite what I want," etc.

(5) It's essence is meaning. When such learning takes place, the element of meaning to the learner is built into the whole experience.

Of two possible aims of education, the transmission of stored knowledge and learning how to learn, only the second is suitable to modern man who must place his confidence, his basic trust, in the process by which new knowledge is acquired.

He goes on to describe two sets of assumptions in education:

Assumptions from current education based on what teachers do, not what they say they wish to do.

a. The student can't be trusted to pursue his own learning.

b. Presentation equals learning.

c. The aim of education is to accumulate brick upon brick of factual knowledge.

d. The truth is known.

e. Constructive and creative citizens develop from passive learners.

f. Evaluation is education and education is evaluation.

Rogers predicts a revolution in education in the next few decades that will challenge the foregoing assumptions. The question for the newer approach is "How can the incorporation of the process of learning and changing be made the deepest purpose of the educational experience?" He then presents assumptions that will replace the previous set.

Assumptions Relevant to Significant Experimental Learning:

a. Human beings have a natural potentiality for learning.

b. Significant learning takes place when the subject matter is perceived by the student as having relevance for his own purposes.

c. Much significant learning is acquired through doing.

d. Learning is facilitated when the student participates responsibly in the learning process.

e. Self-initiated learning, involving the whole person of the learner,--feelings as well as intellect--is most pervasive and lasting.

f. Creativity in learning is best facilitated when self-criticism and self-evaluation are primary, and evaluation by others is of secondary importance.

g. The most socially useful learning in the modern world is the learning of the process of learning, a continuing openness to experience, an incorporation into oneself of the process of change.

To optimize the chance that this second set of assumptions will be adopted and acted upon by the teacher and learner, Rogers describes what he calls "attitudinal sets" necessary or to be hoped for in the teacher. These are "...realness or genuineness; an acceptance of the student; and empathic understanding." The teacher or facilitator must be a real person, be himself, show his feelings (enthusiasm, boredom, anger, etc.) and allow the student to do the same. He cannot be seen only in the "teaching role." He must give evidence that he prizes the student's opinions, feelings and individuality. A teacher must have a "...sensitive awareness of how the process of education and learning appears to the student," to improve the likelihood of personally meaningful learning occurring. Rogers cites research that tends to confirm that when these characteristics are present in psychotherapy, learning is facilitated, and suggests that they should be appropriate in education.

Asahel D. Woodruff (40) in "Cognitive Models of Learning and Instruction" suggests that formulation of instructional programs in the past has suffered from the absence of underlying concepts of human behavior and learning.

Recent developments have improved the possibility of formulating useful models of instruction (41). These are: the understanding of the role of value in human behavior, the recognition of concepts as mediating variables in behavior, and in the field of communication, the differentiation of the verbal process from the cognitive process. Hoban (25) says that it is a fundamental error to assume that "communication is the transmission of meaning." Meaningful sets of symbols may be transmitted, meaning can not. Woodruff cites PSSC Physics indirectly as an example of the process of making visible to the student, with experiments on physical objects, the phenomena from which knowledge finders derive verbal statements about these phenomena. The student can then experience his own perceptions and form his own conceptualizations. This provides a link between knowledge and behavior, often missing in the past.

Woodruff goes on to offer "Assumptions Relevant to Behavior and Learning." His models rest on these assumptions:

1. Human behavior is characterized by the qualities of a cybernetic system.

   There is referential input (input from real objects and processes, not from symbols which represent them); storage and internal manipulation of the input; the possibility of response during the manipulation to a communication input which has the sole possibility of guiding the attention of the subject; purposive output; and feedback from the output action into the perceptual channels.

2. The referential input is the sole source of percepts which become concepts. Referential input consists of literal sense perception of real objects and processes. Communications input can not perform this same task since it is only a verbal description of these sense perceptions. Lecture and discussion are communication inputs.

   Referential input becomes dominant when ever a person is placed in a new environment for which he has no existing cognitive background. Referential input need occurs over and over again in school, even in graduate school.

Verbal input can lead to concept maturation only when the essential bits of perceptual meaning are present. When they are not, referential input is necessary regardless of school level.

3. The internal manipulation and storage process has some dimensions:

    a. It may be either subconscious or recognized in various degrees.

    b. It varies from vagueness of first impressions to the clarity of mature concepts.

    c. It varies from subjectivity to objectivity.

    d. It varies from no verbalization to complete verbalization.

    e. It ranges from concreteness to "constructness", that is, from mental images of concrete referents to extensive mental constructs in three directions; categorization based on recognition of similarities of structure (generalization); integration based on recognition of processes and consequences (principles); and the discovery of qualities of either structure or processes, which are then abstracted and treated as reals.

    f. Principles may be used by means of transfer, to solve problems in unfamiliar situations.

    g. It varies in degree of inventiveness and also in the quantity and quality of artistic originality.

4. Recognition of the instrumental value of process, structural referents, and qualities is part of the internal-manipulation process.

Through feedback from vicarious or actual trial of a person's concepts above ways of behaving, the empirically substantiated value becomes part of the concept and gives rise to motives. Feelings are the internal responses to the satisfying or annoying dimensions of the trial phase of behavior. This part of the response is the source of value judgement.

5. Symbolization, or verbalization of meanings, is part of the internal-manipulation process, and verbal communication is the external manifestation of the symbolization.

What has come to be known as the teacher-pupil interaction process is a special use of verbal communication to stimulate validity, maturity and verbalization of concepts, discovery of principles, and orginality in the internal-manipulation process of the student.

6. Behavior output is mediated by concepts in ways which are purposive to the reduction of stimuli, the satisfaction of underlying needs, and the attainment of goals.

    The operation of the behavior is independent of conscious awareness of what is going on. That is how perceptual meaning is acquired, concepts are formed, and decisions are made with and without awareness. Awareness does not change the basic process, but permits the intrusion of objectivity through the use of learned criteria and safeguards.

The model presented below and utilized in the experimental study rests on these assumptions. The model (see Figure 1) in turn furnishes a source of hypotheses against which existing relevant data can be laid and which can be subjected to empirical test.

Stimulation is the first stage (sensory intake) of this cycle. Careful distinction must be made between symbolic stimuli which are primarily verbal in nature, and are triggering devices for stimulating recall of percepts or concepts already stored, and referential stimuli that arise from objects or events and are inputs for cognitive meaning. Teaching often requires parallel application of both kinds of stimuli if cognitive meanings are not already present.

Storage is associated with stage three and involves the storage and manipulation of both symbols and concepts. Teaching involves using symbolic and verbal processes of interaction with students. These achieve guidance of the internal-manipulation of conceptual process, decision making, trial of learned concepts in realistic situations, and interpretation of feedback from those trials. This in turn cultivates higher forms of thought and useful originality.

Original behavior emerges as another important face of storage and manipulation. Two elements contribute to original behavior. One is imagination (5). The other is composed of various concepts of technical

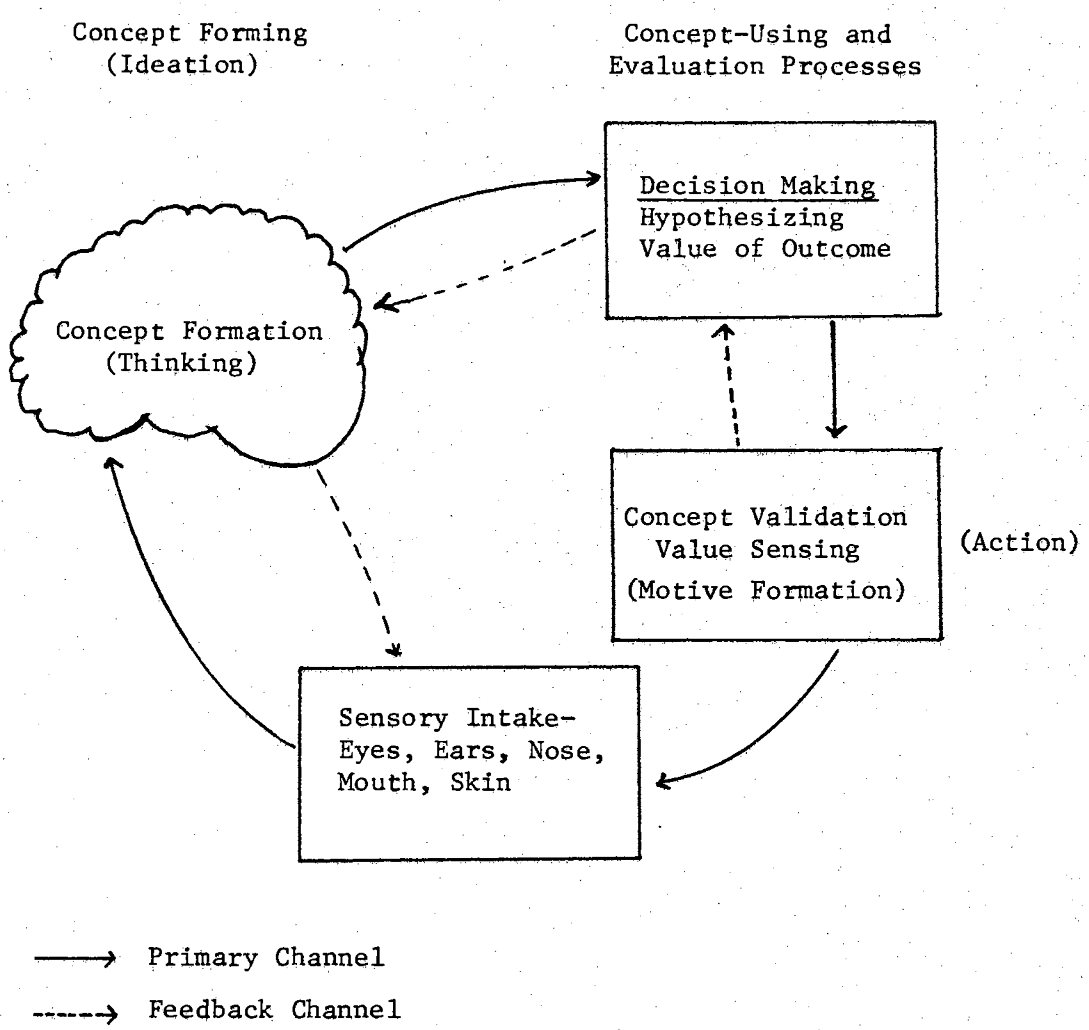


Figure 1. A Model of the Behaving Learning Cycle

processes and structures which must be used to give effective expression to original ideas or imagination. Diverse examples of areas that depend on technical processes would be harmony, artistic composition, high energy physics, and painting (6).

One dimension of the behaving learning cycle (18) most often neglected in teaching is concept validation or shaping up. Woodruff states:

> Concepts that are formed without empirical trial take on satisfactory meaning to the person solely on the basis of the discussion of percepts acquired visually or orally. This discussion process, typical of classroom talk, can yield a concept which will satisfy an achievement test question, but which may not enable him to carry out an adjustmental act in a real situation.

The student knows but cannot act. School learning frequently lacks the trial stage of the learning cycle.

Woodruff suggests that without the doing or action stage, or motive formation stage, feeling will not occur. He goes on to state:

> The perception of the positive or negative instrumental value of an object or process, whether that perception is intuitive or clearly conscious, furnishes an input which becomes part of the concept of the object or process. This is the origin of value, both positive and negative. Instrumental value is the foundation of motive in all of its forms: interest, sentiment, wish, major value, ideal, goal of any degree of immediacy or remoteness.
>
> Feeling reaction, being rooted in adjustmental acts, does not occur when no adjustmental states are involved. They occur most regularly and most vividly at the trial stage of the learning-behaving cycle since that is basic stage of adjustmental action. Once established through empirical experience, feelings can be reactivated when a particular concept is recalled, and reenacted emotional reaction often occurs when an emotionally loaded concept is being discussed.

Emotions can play a part in academic discussions, but they are the result of previous empirical experience rather than generated as a part of the discussion. Woodruff adds, "There is nothing so noticeable as the neutrality of feeling or in other words plain apathy, which students feel for subject matter when their total experience consists of class presentation and class discussion (the storage and manipulation stage alone)."

Woodruff lists as the main objective of formal instruction, to have students learn about selected aspects of their world. This is accomplished under a teacher's guidance by encouraging concept formation which leads to objective behaviors.

In accordance with these ideas Woodruff makes three assumptions about instruction:

1. Behavior and learning are approximately as described heretofore, and the formal instructional process must take its shape from the contours of foregoing models. It must, in effect, be the counterpart or complement of the process of learning and behaving.

2. Instruction serves two ends: First, it produces changes in the adjustmental behavior of the learner, largely by helping him acquire concepts. Second, it makes the student think and learn independently. It should be noted that all behavior is regarded as adjustmental, that is it is aroused by need and is an attempt to meet the need.

3. The instructor is present for the purpose of guiding and facilitating the learning process toward the achievement of certain defined goals of the educative system. The broad goals are generally set up in the form of behaviors to be attained, and curriculum content is chosen to produce the concepts which will in turn produce the desired behaviors.

In describing the act of instruction Woodruff made the following important comment:

> Subject matter consists of the real world 'out there', not of books, bodies of information, lectures, or any of the other verbal and symbolic materials that have in the past dominated the school. Information can be memorized, but it does not lead to concepts and understandings.

In this study the major use of much of this material was to describe the constraints imposed upon the teaching and learning of introductory physics assuming that the student is an idiosyncratic system, whose learning and behaving characteristics are described by this model and with the realization that successful efforts in the teaching and learning of physics depend upon a careful match to the student's system.

Cognitive theorists place great weight on the need to enhance and capitalize on individual differences within the student group. Ericksen (15) suggests that the most powerful effect can be expected from those instructional changes that release and give greater freedom to individual - difference variables, such as a student's motivation, his memory, and the degree of meaningfullness he can attach to informational stimuli given by lectures, books, films, slides, demonstrations and the like.

Gagne (23) likewise gives the learner an independent place in the teaching - learning cycle. He describes instruction as the institution and arrangement of external conditions of learning in ways which will optimally interact with the internal capabilities of the learner, so as to bring about a change in these capabilities. He goes on to suggest that there are varieties of change called learning and that each variety in turn calls for a different variety of instruction.

Introductory Physics and Course Development

In a large university it is often expedient for reasons of time, finances, manpower, and facilities to offer large lecture sections of introductory courses. This was true of Descriptive Physics 1014 which had approximately one hundred fifty students per section, and was the course involved in this study.

If the major goal of such a course is to transfer knowledge or facts about physics to the student, research findings reported in McKeachie's (29) article on "Research on Teaching at the College and

University Level", tend to support the use of such sections. Of eleven studies that tried to detect differences in knowledge gained between lecture and lecture-discussion, no advantage was shown for the lecture-discussion group. Information transfer was equally effective in large and small groups.

If, however, attitude and emotional changes constituted part of the goals of a course, McKeachie reports that more positive results were gained by lecture-discussion. This study had as a major goal, effecting more than just cognitive growth, so perhaps discussion and other types of student response should play an integral part.

Dubin and Tareggia (13) looked at forty years of research regarding comparative studies of methods of teaching at the college level and offered this observation:

> In the foregoing paragraphs we have reported the results of a reanalysis of the data from 91 comparative studies of college teaching technologies conducted between 1924 and 1965. These data demonstrate clearly and unequivocally that there is no measurable difference among truly distinctive methods of college instruction when evaluated by student performance on final examinations.
>
> It may very well be that the most pervasive commonality among teaching methods is the employment of and dependence on textbooks and other reading materials. Perhaps the "no difference" results of comparing teaching methods can be attributed largely to the powerful impact of textbooks which cannot be washed out by any known methods of instruction.

McKeachie (29) discussed motives within the student that acted to reduce differences between groups exposed to different teaching methods. Among these are interest, parental expectation, peer group acceptance, and grades. Grades may well be one of the strongest motives, leading the student toward learning whatever is required to get a good grade.

McKeachie (29) does offer hope when he says that in spite of the many findings of no significant difference in effectiveness between lecture and discussion, those studies which have found differences make surprisingly good sense. In only two studies, was one method superior to the other on a measurement of knowledge of subject matter; both studies favored the lecture method. However, six other experiments finding significant differences in favor of discussion over lecture, the measurement was made with instruments other than final examinations.

A survey made by this researcher of the reports of new courses and course development programs reported in the American Journal of Physics during a twenty year period from 1949 through 1969, produced the following results. During the first ten year period there were fourteen reports of new or at least innovative course ideas. Each article provided a fairly careful description of the course which included the topics offered, the amount of laboratory, the frequency of class meetings, methods of teaching, character of the testing program, and the advantages to the student and the physics community of that particular approach.

In only two cases were formal course evaluations reported. Typical of the work reported during this period are the following examples: Formal et al. (19) in 1949 offered a description of a two-year course in Basic Elementary Physics that had evolved over a ten year period. He made no mention of any formal evaluation of the course. C. C. Clark (8) described a course in College Physical Science that he had taught for fifteen years and had offered to several thousand students but summarized his results by saying, "I think that we have achieved at least two results; students no longer think that science is miraculous, and in their daily lives, in business and citizenship they most likely use a measure of rational thought and impartial thinking, rather than long hunches, a long-shot chances, guesses and biased opinion." Fitzsimmons (18) in his description of a Laboratory Course for Seniors in Physics offered the opinion that the course was needed and did inspire or maintain high student interest.

During this same period, there were two courses reported with a discussion of evaluations. Peck and Haisley (30) described A One-Semester Physics Course for Liberal Arts Students; their evaluative procedures included: objective evidence of student's performance, subjective impressions of the progress of the course, and student comments volunteered in response to questionnaires distributed during three different years. This information was used to modify the course for later offering. J. K. Major (28) in describing a physics offering in Yale's Directed Studies Program, did suggest an end of the year evaluation by survey to be used to modify the course so that it might serve majors in science as well as others.

During the second ten year period (1960 to 1970) the score improves. Of the twelve course descriptions offered, seven make a definite reference to testing or course results, and one even goes so far as to comment on national applicability of the approach.

Caughlan and Towe (11) in an article titled "Laboratory Performance Testing," describe the development of a short laboratory experiment similar to the experiments completed in the regular laboratory program, that could be used to test students' knowledge and laboratory skills. The results of these tests were used to grade students and modify the course called Contemporary Physics I and II, in which Scientific American Off-Prints were used as texts. They offered personal opinions as to the success of the course, suggested changes that would be made, and indicated that it had become a permanent part of the curriculum after only one year's use. None of these conclusions, however, was based on a formal testing program.

Alan Portis (33) offered the first real reference to careful testing of a college physics course in his description of the Berkeley Physics Laboratory. After an initial trial of the Berkeley Physics materials with two groups of forty students, it was turned over to professors who had had no part in developing the course materials, to offer it to thirty-five groups of twenty students each. Feedback from this trial was used to modify the materials and approach, and the course was then offered as a nationally applicable approach to physics laboratory work. Alan Portis even suggested "national applicability" as the reason for these steps, as well as a fear that earlier trials also included the "Hawthorne Effect."

H. R. Crane (11) offered one of the liveliest reports on introductory physics in an article he titled "Experiments in Teaching Captives." His goal was not to modify the subject matter nor the method of presentation but to change the ground rules by which the student approached learning. His general boundary conditions were that faculty time not be increased, and rigor not be sacrificed. The new features tried were:

1. Substitution of open-office sessions for one half of the class meetings.
2. Establishment of a student self-help room, designed to allow students to help one another.
3. Production of a weekly handout indicating the schedule, problem work, points of difficulty and occasional humorous comments.

Professor Crane felt (again without formal testing) that "...finite progress was made," and in particular a larger fraction of the students developed a lively interest in the subject than had been the case previously. He did state, also, that no attempt was made to compare the amount of learning gained by this method as opposed to the "old method," because learning was a very complicated quantity, not definable in measurable terms.

His parting shot included a plea for more experimentation in the strategies of running big courses. Little has been reported in this area in comparison to that which has been published on the tactics of subject matter presentation, or topics chosen, etc.

Fryshman (22) in describing a laboratory course for nonscience majors, suggested that quantitative comparison of the accomplishments of students in the two different approaches he used was unfeasible. He was willing to use such indicators as interest, enthusiasm, and voluntary outside reacting as evidence that students gained more from the new sequence.

Two other examples of course evaluation were given, each for courses offered only once. Donald Snyder (38) developed an experiment-oriented general physics course and gave it to eight students out of a sixty-five student group and evaluated the course via a questionnaire three and one-half years later. He suggested that evaluation in the first year would have been premature as students would have had no chance to find out if the course suited their needs. On the basis of the mailed questionnaire, he did feel the course should be offered again in the future.

Bertman _et al_. (3) offered an elementary physics course in which the students attended only one lecture per week then spent the remainder of their class time in the laboratory doing experiments of their own choice. The claim was that this semi-tutorial approach freed the well-prepared students and allowed the others to get extra help. Again, as in the Snyder course, no formal studies of the results of the course were offered; some indications of student enthusiasm and interest were given, but the course had been offered for only one semester.

A well planned approach reported during the second decade of this survey was one offered by K. L. Warsch (39) in which oceanography was chosen as a way of presenting a physical science course in a context more interesting to the students. The other modification made was a reversal of the order of presentation of the discussion of each principle. Normally in physical science the basic law is presented first, followed by some general discussion, and then concluded with a discussion of practical applications. Warsch reversed this procedure. He presented observable phenomena, described these in great detail, discussed the extent and importance of the phenomena and only as a last step introduced the basic principle behind the phenomena.

His appraisal of the results, made by comparing the experimental section with the standard sections, included:

1. Test evidence: the experimental group made a better response.
2. Anonymous evaluation forms: there was a unanimous urging on the part of the students that this course be offered again.
3. Other physical evidence of success: the students were reading outside articles on oceanography, and doing so with ease, enjoyment, and comprehension, as indicated by their asking perceptive questions. There was also reduced student antagonism toward physical science.

One of the newest efforts in introductory science is the course <u>Physical Science for Nonscientists</u> (PSNS) (34) which was an outgrowth of the 1963-1964 conference on physical science for nonscience majors sponsored by the Commission on College Physics and the Advisory Council for College Chemistry. One of the groups for which this course was designed was elementary teachers, although it was hoped that it would be used more widely. Experiments were an integral part of the textbook and were of three kinds; take-home experiments, chair-arm experiments, and some to be done in a regular laboratory setting. The important point is that, to succeed in learning the science, the students must do these experiments. The answers or results are not provided in the textbook and later work depends upon them. This approach seems to be well matched to the Woodruff model of the Behaving and Learning Cycle although no mention of this occurred in the article. The teacher can provide verbal guidance at all levels as the experiments progress, but the student is actively involved on his own behaving learning cycle.

In the review of the literature on physics course development, this researcher was unable to find any reference to a theoretical model being used as the basis for the development of a teaching or course strategy.

Hearn et al. (24) in a private communication report on an effort to match current views in cognition and learning especially those of Jean Piaget concerning invariance, with a method of presentation of materials and topics in physics for the nonscientist. Preliminary efforts involved a committee of faculty members from the Departments of Computer Science, Physics and Psychology. According to a letter accompanying the report, this approach has been tried with very small groups (10 or less) and has been conducted on a nearly individual basis. No assessment of the results was included in the report.

A closing comment is to be found in an article by John Fowler and

Richard West (11).

> "It may well be that the nonscience major is the most difficult challenge that physics educators face. Is it an important one? As physicists, we have to believe that it is. For, if present trends continue, our discipline will slip further outside the mainstream of liberal education."

It is evident from the literature search that there have been no reported efforts to design an introductory physics course using a behaving and learning model as a basis for choosing teaching strategies.

The following chapter describes the procedures to be used based on the Behaving and Learning Cycle and the hypotheses to be tested upon application of these procedures.

CHAPTER III

DESIGN AND METHODOLOGY

Descriptive Physics 1014, was the course involved in this study, is a one semester nonlaboratory, four credit hour introductory course. It is offered for the nonscience major in as much as it cannot be used as a basis for additional course work in physics. The enrollment is approximately six hundred students per year, divided into sections of generally one hundred fifty. The method of instruction has been lecture demonstration involving liberal use of apparatus and audio visual materials. Grades are determined through monthly examinations and the presentation is nonquantitative.

Description of the Sample

The characteristics of a parallel student group were obtained by a voluntary questionnaire (see Appendix B) distributed to a one hundred sixty-eight student section of Physics 1014 in the Fall of 1969. The information requested was: a) the college in which the student was enrolled; b) his or her class in school; c) science and mathematics courses completed in high school and in college; d) reasons for taking the course and e) who was finally responsible for the decision to enroll in the course.

The students were almost evenly divided between the Colleges of Arts and Sciences (40%) and Agriculture (50%). There were a few from Education, Business and Home Economics, but this group constituted less than 10% of the population. Their distribution by class: 10% Freshman; 35% Sophomores, 36% Juniors, and 17% Seniors.

Ninety percent of the students listed the course as being required in their degree program while 10% indicated that they took the course as an elective. The advisor had recommended the course to 39% of the students, while 50% included themselves as partially or totally responsible for the decision to take the course. Approximately 8% listed other persons as the major factor in their choice while 3% indicated the influence of a high school teacher. This question was rather loosely phrased to the group so that these results must be taken as only a rough indication of the student's reasons for taking Physics 1014.

The academic background of the students can be indicated by the course work taken prior to enrollment in Physics. Their high school backgrounds (measured by the student responses to a questionnaire, not transcripts) show that 100% have had Algebra I, 80% Algebra II, 75% some Geometry, 33% Trigonometry, 60% Chemistry, and 78% General Science, but only 2% Physics. Their college work showed (not a transcript response) that 50% had taken College Algebra, 1% Geometry, 1% Trigonometry, 3% some Calculus, and 38% General Chemistry. These people were indeed beginning physics students.

Design of the Study

The general studies physics course should be challenging, interesting, nondiluted, and couched at a level commensurate with the skills, background and needs of the students involved. It should cause the students to feel that physics is a valuable introductory science course that could be chosen as readily as other offerings at the same level, as part of their general education.

S. E. Erichsen (15) characterizes the major obligation of a university as "teaching a student how to think," by helping him acquire abstract relationships fundamental to a particular discipline through thinking rather than memorization. The learner must be free to abstract by establishing his own ideosyncratic pattern of subjective associations.

This means studying only a limited number of topics or ideas, and allowing the student as suggested by Arons (1) a chance to suggest alternative ideas and to test them at least in thought and argument, if not in experiment, before rushing him to the right answer and to the end results. H. R. Crane (11) suggests other advantages of reduced coverage. It gives mediocre students a better change of catching on before the next topic commences, more time can be spent on systems rather than components, and things can be interconnected rather than left as discrete bits of information. Since creativity involves the habit of always looking for many ways, including unconventional ways, of applying each new principle or fact learned, time must be available to the student if this is to occur.

Introductory physics can fulfill Erichsen's, Aron's, and Crane's suggestions only through limited coverage, because abstraction by the student requires more time than teaching or lecturing by the professor.

The goals listed above were the same for both sections of Descriptive Physics. The difference lay in the approach used in presenting the material and in working with the students.

This study involved two teaching strategies. One group was taught by a method to be referred to as Lecture-Demonstration, the other was taught by a method referred to as Presentation-Discussion-Interaction.

A description of the two approaches follows:

1. Lecture-Demonstration Group (LD).

Physics concepts were presented by lecture with the use of appropriate demonstrations and apparatus. These were developed carefully and an attempt made (relying on the experience of the teacher involved) to anticipate student difficulties and questions and to answer these in the original presentation. However, spontaneous questions were courteously received and answered carefully. Convergent questioning (toward the lecture topic) was encouraged.

When a concept could be presented using demonstration apparatus, the presentation was carried through to its conclusion and all details, measurements, and observations clearly shown.

Problem and reading assignments were suggested and, as before, carefully discussed in class trying to anticipate student difficulties and questions. No homework was collected for grading and no direct check made to see that it was being done.

Help was available to the students wishing it at designated times and places, and they were encouraged to consult either instructor.

Four examinations were given and used to determine the grade for the course.

The information sheet given to the students at the beginning of the semester, explaining many of these course characteristics, is shown in Appendix A.

2. Presentation-Discussion-Interaction Group (PDI).

Physics concepts were briefly presented using appropriate demonstration apparatus when possible. Questions from students were encouraged at all points in the presentation.

Following the brief presentation, variations of the topic were used to raise questions which would force student response (frequently by vote). The student forced to make a decision was involved in the action phase of the Behaving and Learning Cycle, and feelings could then become a part of the process. When the question was finally answered both the student and the instructor had an indication of the level of understanding of that topic.

As an example, after the instructor had discussed Newton's Laws of Motion, an air track was set up and a glider caused to travel its length at a constant speed. The question then asked was: "Is there an unbalanced force acting on the glider to keep it moving?" The students were asked to vote on the possible answers. Some argued that there was an unbalanced force, some, correctly maintained that there was not.

Regardless of whether the student was in the group that was right or wrong, his willingness to enter into an adjustive act (making the choice between the possible answers on the basis of his understanding of Newton's Laws) allowed feelings to become associated with the law. Had this same information been part of a lecture (verbal input only, no request for action on the part of the student) his ability to and wish to remember it may have been at a lower level. The trial state (shaping up) of learning would have been bypassed in favor of a final answer. The adjustmental act allows completion of the student's Behaving and Learning Cycle.

Questions of both a divergent and a convergent nature were encouraged. The students were allowed to raise questions that in turn guided the presentation, whereas in the LD group the same question may have been anticipated and answered before students could raise it.

Because student learning is ideosyncratic and there are a large number of these students facing a single teacher, encouraging some of the students to raise questions hopefully guaranteed that these questions were truly representative of the students, and did not depend solely on the teacher's guess, albeit an intelligent one, as to the real problems facing the students. This is a questionable assumption and will not be tested. However, it could be an important influence.

Problem work and reading assignments were given but not collected for grading. These were carefully discussed in class in response to student questions.

Feedback was an important ingredient in the Interaction process and included teacher's requests for votes on raised questions and responses on bi-weekly handouts.

The LD students had four major examinations totaling four hundred points. The only examination common to both groups was the final examination, worth 100 points. The remainder of the points gained by the PDI Group came from handouts. Sample handout questions are given in Appendix F. The handouts consisted of two or three questions to be answered in sentence or paragraph form. This complemented the interaction process or trial stage of learning in that an almost correct response could be given partial credit (therefore encouragement) whereas an incorrect multiple choice response would gain the individual no credit. Examples of the types of questions asked on these handouts are shown in Appendix F.

The use of this approach gave the teacher access to the student's Behaving and Learning Cycle and allowed guidance of this process on a fairly regular basis apart from class interaction.

The points gained by the LD Group on the three exams and the points gained by the PDI Group on handouts were not used in this study's comparison of the two groups.

Outside help was available and the students were encouraged to visit with the instructors involved with either section. Only one major examination was given the PDI Group. This, the final examination, was given in both sections and had equal influence on the semester grades in each section.

Copies of the General Information Sheets given to students may be found in Appendix A.

Hypotheses

The hypotheses tested in this study were:

1. There is no significant difference (0.05 level of confidence) in the knowledge gained by students in the LD Group and those in the PDI Group, as measured by a pre-test and post-test administered to both groups.

2. There is no significant difference (0.05 level of confidence) in the knowledge gained by the LD and PDI students enrolled in the various colleges.

3. There is no significant difference (0.05 level of confidence in the knowledge gained by the LD and PDI students of different class levels.

4. There is no significant difference (0.05 level of confidence) in the knowledge acquired by LD and PDI students having significantly different high school mathematics and science preparation.

5. There is no significant difference (0.05 level of confidence) in the knowledge gained by the LD and PDI students with different back-

grounds in college algebra and chemistry.

6. There is no significant difference (0.05 level of confidence) in the attitudes toward the course expressed by those students in the LD Group and those in the PDI Group, as measured by an attitude questionnaire administered to both groups at the end of the semester.

7. There is no significant difference (0.05 level of confidence) in the knowledge gained by male and female students in the LD and PDI Groups.

Independent Variables

Many variables were common to the two approaches. The textbook Conceptual Physics (2) was used in both sections, the same topics were presented, essentially parallel homework assignments and the same pretest and final examination were used. The same lecture demonstration materials were used in both sections although the methods differed. Both sections met in the same lecture hall, 12:30 PM, MWF and 1:30 PM Tu.; while the PDI Group met at 2:30 PM, MTWTh.

Coordination between the two sections was insured by almost daily meetings between the instructors. Too, the instructor of the PDI Group frequently attending the LD class sessions.

The major difference lay in the teaching strategies adopted for each group, which was the basis for this study. This lead to the effort to detect differences in outcome with the tests and measures to be described later.

A second significant difference arose from the use of separate instructors for the two sections. Efforts were made during the semester to minimize the difference by having each section taught by the other instructor a number of times so that the students came to know both. With this effort and daily meetings between the two instructors on pace, presentation, and choice of topics, the difference due to instructors may have been greatly reduced. No effort to measure the influence of separate instructors was made.

A third difference involved the instructor's methods of allowing the student to keep track of his or her own course progress. In the LD Group tentative grade scales were associated with each of the three exams when they were returned to the students. In the PDI Group bi-monthly total point distribution curves were shown to the class with tentative grade divisions shown.

There were a group of differences which were detectable and presumed controlled by virtue of random distribution between the LD and PDI Groups. Verification of this was made with chi-square (χ^2) test for random distribution. These variables were: sex, college in which the student was enrolled, the student's class level, the size of his high school graduation class, the reason for his enrollment (required or elective), who recommended the course, who made the final decision to take the course, high school science and mathematics course background, and finally the college science and mathematics course background. Information on these variables was obtained via a questionnaire distributed at the beginning of the course. A copy of the questionnaire is provided in Appendix B.

Instruments Used

The knowledge of physics that a student brings into the class would certainly seem to be a major factor in his cognitive growth. To detect this a pre-test was prepared using questions relating to topics and concepts in physics that would be introduced during the course. The test consisted of thirty items in a multiple choice format. A copy of the pre-test is provided in Appendix C. The test was administered on the second day of class and presented to the students as a diagnostic tool to be used to detect the student's knowledge of physics and as a guide to the level of presentation. The students were told it would have no influence on their grade and neither the results nor the exam were available to the students after it was administered.

The knowledge of physics that a student possessed after completing the course was measured by administering a final examination covering the material associated with the semester's work. The final examination consisted of fifty questions in a multiple choice format. Thirty of these questions were the pre-test questions. Comparison of the knowledge gained by students in the two sections of Descriptive Physics was made using the pre-test and post-test scores.

Another factor which may well influence knowledge and attitude is educational set. Siegel and Siegel (16) postulated the existence of and created a test to measure educational set. Their claim is that, "educational set comprises a continuum defined at the poles by predispositions to learn factual content on the one hand and conceptual content on the other." In a report of the use of the Educational Set Scale (ESS), it was found that in a course emphasizing intrinsic learner conditions rather than extrinsic environmental conditions, conceptually set students performed better than factually set students ($P < .05$).

The Behaving and Learning Cycle is an intrinsic phenomenon (within the individual) and this study investigates an approach to teaching which, theoretically, more closely matches this internal cycle. Under the Siegel and Siegel hypotheses a conceptually set individual should respond to this approach more successfully than a factually set individual.

The Educational Set Scale was administered to all students on the first day of class. The test is a forced-choice, objectively scored, group inventory for assessing educational set. The student is presented with groups of three topics all related to some course such as Government, Social Studies, Natural Science or others. He is then asked to rank the topics in each set of three indicating the extent to which each interests the student. The rankings are most, intermediate, least. A copy of the ESS is provided in Appendix D.

The reliability of the set scale was established using the split-test (odd-even) technique which yielded a value of .94. Test and re-test reliability using a 66 student group was .92 with the time interval between test administration ranging from 1 to 5 days.

The factors measured by the Educational Set Scale are relatively independent of the factors assessed by the American College Testing Program Composit Score and certain of the Guilford creativity tests (16). The student's ESS score was used in conjunction with pre-test post-test analysis of knowledge gained, as one of the covariates.

A measurement of the attitudes of the students in each group was made using a locally produced Attitude Measure (see Appendix E). This measure consisted of 21 statements relating to the Descriptive Physics course. The students were asked to indicate their level of agreement or disagreement with each statement on a five point scale. The statements were selected in terms of the goals of the course and predicted outcome attitude differences in the two groups suggested by the teaching-learning model used.

Approximately half of the statements were considered negative statements with respect to the goals of the course the other half were positive statements. If there was high agreement with the positive statements and low agreement with the negative statements the student was said to have a positive attitude toward the course. If there was low agreement or disagreement with the positive statements and high agreement with the negative statements the student was considered to have a negative attitude toward the course.

Scoring of the individual statements depended on whether it was considered a positive or a negative statement. If it was a positive statement, the weight used was 5, 4, 3, 2, 1 as shown on the statement form. A high value indicate a high positive feeling, a low value, a negative feeling toward the course. If the statement was a negative statement, the weighting of the responses was reversed, 5 = 1, 4 = 2, 3 = 3, 2 = 4 and 1 = 5. In this manner a low response to a negative statement generated what was in effect a positive response. The result of this scoring scheme was a range of final scores for the individual which could begin at 21 and would indicate the most negative response to a score of 105 which would be the highest positive score. This whole procedure is called the method of summated ratings, and is credited to Likert (27).

Edwards (17) warns that one may not in general make an interpretation of an attitude score on a summed-rating scale independently of the distribution of scores of some defined group. The neutral point on a summed-rating score is not the midpoint of the possible range of scores.

The absence of such a point is not a handicap if two large groups are being compared. It is a handicap in attempting to pass judgement on the score of a single individual. In this study only comparison of mean scores of reasonably large groups will be considered, with the smallest group being ten.

The Attitude Measure was administered following the final examination. The students were told that it would not be looked at by the instructor until after the grades had been submitted to the Office of the Registrar.

Anonymity was assured by there being no request for the student's name or class roll number. The only information requested apart from the student's response to each statement was his college, class, and gender.

Statistical Procedures

There are a number of factors that may have influenced the cognitive-gain or the attitude of the students in the course. These factors were not measured but were effectively controlled if they were randomly distributed throughout the two groups.

The following factors were checked for randomness of their distribution. These were, sex, the college in which the student was enrolled, students level in college, the size of his high school graduating class, his reason for taking the course, who recommended the course, who made the final decision to take the course, his high school course background and his college course science and mathematics background. Randomness was investigated using a chi-square (χ^2) test.

The first hypotheses dealt with cognitive gain and a comparison of the cognitive gain of the LD and PDI Groups was made.

The statistical procedure used was analysis of covariance. The variate was the post-test score of each student, while the covariates were the pre-test score and the ESS score. Covariance comparison of the two groups resulted in adjusted mean post-test scores which yielded an F ratio test of the adjusted treatment mean square divided by the error mean square to be tested for significance at the 0.05 level.

Additional comparisons of adjusted means were made by sub dividing the LD and PDI Groups by the College in which the student is enrolled and by class in school. These are hypotheses 2 and 3.

The influence of high school and college science and mathematics courses (hypotheses 4 and 5) was studied by dividing each of the sections into groups who had or had not taken various combinations of these background courses. The adjusted mean post-test scores were then compared, by returning to analysis of covariance as the statistical procedure.

For the college courses the groupings chosen were: (1) students who had taken college chemistry; (2) students who had taken college algebra; (3) students who had taken both chemistry and algebra; and (4) those students who had taken neither algebra nor chemistry.

In the case of the high school course background a different scheme was employed. A majority of the students indicated that they had taken algebra in high school so this was ignored. There remained geometry, trigonometry, general science, chemistry, and physics, to be considered. The divisions then chosen were; (1) those students who had taken one of these courses; (2) two courses; (3) three courses; (4) four courses; (5) five courses; (6) none of these five courses.

The sixth hypotheses involved the attitudes of the respective groups. The first comparison was an analysis of variance comparison of mean attitude scores for the two groups which provided an F ratio to be tested for significance at the 0.05 probability level.

Further division of the two groups by college and by class allowed additional analysis of variance comparison of mean attitude scores. If significance was detected at the 0.05 level of confidence, t tests were used to compare particular sets of means.

A comparison of group responses to each of the 21 questions was carried out using t tests. This allowed determination of the source of the real differences in attitude between the LD and the PDI Groups.

The seventh hypothesis required a comparison of the adjusted mean post-test scores of the males and females in the two groups. An analysis of covariance comparison was made.

The statistical tests were carried out with the Oklahoma State University IBM System/360. The analysis of variance and analysis of covariance were in library programs, taken from the U. C. L. A. Biomedical Programs; Program BMDOIV Analysis of Variance for One-Way Design-Version of June 15, 1966 and BMDO4V Program of Analysis of Covariance-Multiple Covariate-Revised October 31, 1968.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

The goals of this study were to compare the knowledge gained by the students in the two sections of Descriptive Physics, their attitudes toward the course at the end of the semester, and to detect any relationship between their success in the course as measured by post-test scores and their background in science and mathematics. The results of the study are presented in this chapter.

Population Distribution

The distribution of the students by group (LD and PDI), College, and class is shown in Table I. This table indicates that the course served students from the colleges of Agriculture, Arts and Sciences, and to a lesser extent Business, Education, and Home Economics.

A chi-square test of the two populations was carried out to see if the groups differed with respect to any of the factors gained through the Questionnaire or with respect to their ESS Scores. A summary of the results can be found in Table II and the individual chi-square tables may be found in Tables III through XII.

Table II shows that the only characteristics not randomly distributed were, "College in which the student is enrolled," and "Who recommended the course." A close examination of the chi-square tables for

TABLE I

POPULATION DISTRIBUTION BY COLLEGE AND CLASS

College	Freshman	Sophomore	Junior	Senior	Graduate	Sub-Total	Percentage
LD Group							
Agriculture	10	16	24	8	--	58	50.9
Arts and Sciences	14	16	12	4	--	46	40.4
Business	2	1	--	1	--	4	3.5
Education	1	1	--	2	--	4	3.5
Engineering	--	--	--	---	--	--	----
Home Economics	--	1	1	---	--	2	1.7
Technical Institute	--	--	--	---	--	--	----
Unclassified	--	--	--	---	--	--	----
Sub-Total	27(23.7%)	35(30.7%)	37(32.5%)	15(13.1%)	--	114	100%
PDI Group							
Agriculture	5	4	13	1	--	23	24.7
Arts and Sciences	15	28	8	3	--	54	58.1
Business	1	2	1	---	--	4	4.3
Education	1	3	4	2	--	10	10.7
Engineering	--	--	--	---	--	--	----
Home Economics	--	1	--	---	1	2	2.2
Technical Institute	--	--	--	---	--	--	----
Unclassified	--	--	--	---	--	--	----
Sub-Total	22(23.7%)	38(40.9%)	26(28%)	6(6.4%)	1(1%)	93	100

TABLE II

SUMMARY OF THE CHI-SQUARE TESTS OF RANDOM DISTRIBUTION OF VARIOUS FACTORS BETWEEN THE LD AND THE PDI GROUPS

Factor	Degrees of Freedom	χ^2 Calculated	χ^2 Tabular 0.05	χ^2 Tabular 0.01	Distribution
Gender	1	0.0002	3.84		Random
Class	3	3.37	7.81		Random
College	4	16.37	9.49	13.28	Not random
High School Graduating Class Size	5	12.47	11.07	15.09	Random ($p > 0.01$)
Required or Elective	1	1.96	3.84		Random
Who Recommended	2	10.47	5.99	9.21	Not random
Final Decision	2	7.71	5.99	9.21	Random ($p > 0.01$)
High School Courses	6	3.62	12.59		Random
College Courses	5	7.82	11.07		Random
ESS	1	1.11	3.84		Random

TABLE III

CHI-SQUARE TEST OF DISTRIBUTION BY GENDER*

Group	Gender: Male	Gender: Female	Row Subtotal
LD	81 (80.96)	66 (66.04)	147
PDI	33 (33.04)	27 (26.96)	60
Column Subtotal	114	93	207 Total

*Expected frequencies in parentheses

$\chi^2 = .0002$ df = 1

$\chi^2_{0.05} = 3.84$

The males and females are randomly distributed between the LD and PDI Groups.

TABLE IV

CHI-SQUARE TEST OF DISTRIBUTION BY CLASS*

Class	Group: LD	Group: PDI	Row Subtotals
Freshman	(26.99) 27	(22.01) 22	49
Sophomore	(40.20) 35	(32.80) 38	73
Junior	(34.70) 37	(28.30) 26	63
Senior**	(12.12) 15	(9.88) 7	22
Column Subtotals	114	93	207 Total

*Expected value in parentheses.

**The PDI senior group includes the one graduate student enrolled.

$\chi^2 = 3.37 \quad df = 3$

$\chi^2_{0.05} = 7.8$

The students are randomly distributed by class, between the LD and PDI Groups.

TABLE V

CHI-SQUARE TEST OF DISTRIBUTION BY COLLEGE*

College	Group LD	Group PDI	Row Subtotals
Agriculture	23 (36.39)	58 (44.61)	81
Arts & Sciences	54 (44.93)	46 (55.07)	100
Business	4 (3.59)	4 (4.41)	8
Education	10 (6.29)	4 (7.71)	14
Home Economics	2 (1.80)	2 (2.20)	4
Column Subtotal	93	114	207 Total

*Expected frequencies in parentheses.

$\chi^2 = 16.37$ d.f. = 4

$\chi^2_{0.01} = 13.28$

The students are not randomly distributed by the college in which they are enrolled. More than half of the χ^2 value arises due to the imbalance of Agriculture students.

TABLE VI

CHI-SQUARE TEST OF DISTRIBUTION BY SIZE OF HIGH SCHOOL GRADUATING CLASS*

High School Graduation Class Size	Group LD	Group PDI	Row Subtotals
0-50	35 (29.07)	18 (23.93)	53
50-100	22 (18.65)	12 (15.35)	34
100-200	11 (11.52)	10 (9.48)	21
200-300	7 (12.62)	16 (10.38)	23
300-500	9 (11.52)	12 (9.48)	21
500+	29 (29.62)	25 (24.38)	54
Column Subtotal	113	93	206 Total

*Expected frequencies in parentheses.

$\chi^2 = 12.4733$ d.f. = 5

$\chi^2_{0.05} = 11.070$ $\chi^2_{0.01} = 15.086$

There is random distribution between the LD and PDI Groups with respect to high school graduating class size if the 0.01 level is chosen.

TABLE VII

CHI-SQUARE TEST OF DISTRIBUTION BY REASON FOR TAKING THE COURSE*

Reason for Taking Course	Group LD	Group PDI	Row Subtotals
Required	100 (96.38)	75 (78.62)	175
Elective	14 (17.62)	18 (14.38)	32
Column Subtotals	114	93	207 Total

*Expected frequencies in parentheses.

$\chi^2 = 1.96$ d.f. = 1

$\chi^2_{0.05} = 3.84$

The reason for taking the course is randomly distributed between the groups.

TABLE VIII

CHI-SQUARE TEST OF DISTRIBUTION BY WHO RECOMMENDED THE COURSE

Recommender	Group LD	Group PDI	Row Subtotals
Advisor	77 (66.09)	43 (53.91)	120
Students	14 (15.42)	14 (12.58)	28
Self	23 (32.49)	36 (26.51)	59
Column Subtotals	114	93	207 Total

*Expected frequencies in parentheses.

$\chi^2 = 10.47$ d.f. = 2

$\chi^2_{0.05} = 5.99$

There is not a random distribution of students when classed by "who recommended the course". The imbalance lies in the distribution of Agriculture majors between the LD and PDI Groups.

TABLE IX

CHI-SQUARE TEST OF DISTRIBUTION BY "WHO MADE THE FINAL CHOICE THAT YOU WOULD TAKE THE COURSE?"*

Final Decision	Group: LD	Group: PDI	Row Subtotals
Advisor	9 (4.98)	0 (4.02)	9
Self	66 (69.73)	60 (56.27)	126
Self and Advisor	39 (39.29)	32 (31.71)	71
Column Subtotals	114	92**	206 Total

*Expected frequencies in parentheses.

**One student did not respond to the question.

$\chi^2 = 7.71$ d.f. = 2

$\chi^2_{0.05} = 5.99$ $\chi^2_{0.01} = 9.21$

There is random distribution of the students classified by who made the final choice that you would take the course at the 0.01 level of probability.

TABLE X

CHI-SQUARE TEST OF DISTRIBUTION OF HIGH SCHOOL COURSE BACKGROUND*

High School Courses	Group LD	Group PDI	Row Subtotals
Algebra I	111 (106.20)	89 (93.30)	200
Algebra II	70 (74.15)	69 (64.84)	139
Geometry	85 (86.42)	77 (75.57)	162
Trigonometry	32 (37.34)	38 (32.61)	70
General Science	76 (74.69)	64 (65.31)	140
Chemistry	65 (60.28)	48 (52.72)	113
Physics	23 (20.95)	19 (19.59)	42
Column Subtotals	462	404	866 Total

*Expected frequencies in parentheses.

$\chi^2 = 3.62$ d.f. = 6

$\chi^2_{0.05} = 12.59$

The students are randomly distributed between the two groups when high school science and mathematics courses are considered.

TABLE XI

CHI-SQUARE TEST OF DISTRIBUTION BY COLLEGE COURSE BACKGROUND*

College Courses	Group LD	Group PDI	Row Subtotals
Algebra	69 (73.44)	61 (56.56)	130
Geometry	0 (1.13)	2 (0.87)	2
Trigonometry	14 (16.95)	16 (13.05)	30
Calculus	11 (9.60)	6 (7.39)	17
Advanced Calculus	1 (0.56)	0 (0.44)	1
General Chemistry	53 (46.32)	29 (35.68)	82
Column Subtotals	148	114	262 Total

*Expected frequency in parentheses.

$\chi^2 = 7.82$ d.f. = 5

$\chi^2_{0.05} = 11.07$

The students are randomly distributed between the two groups when college course background in mathematics and science is considered.

TABLE XII

CHI-SQUARE TEST OF DISTRIBUTION BY ESS SCORE

Educational Set	Group LD	Group PDI	Row Subtotals
Conceptual	89 (91.97)	78 (75.03)	167
Factual	25 (22.03)	15 (17.97)	40
Column Subtotals	114	93	207 Total

$\chi^2 = 1.11$ d.f. = 1

$\chi^2_{0.05} = 3.84$

The students are randomly distributed between the two groups when considering ESS scores.

each of these characteristics indicated that the non randomness of distribution arose in both instances from an imbalance in the number of Agriculture students in the two groups. Agriculture students indicated that their advisor was the major recommender of the courses in greater proportion than Arts and Sciences or the other students. In the LD Group 84% of the Agriculture students indicated their advisor as recommender, while by contrast only 54% of the Arts and Sciences students indicated their advisor as recommender. In the PDI Group the values were: Agriculture 70%, and Arts and Sciences 41%.

It is the conclusion of the investigator that these students were randomly distributed with respect to the majority of these factors and that statistical techniques which depend upon random distribution may be used.

Knowledge Comparisons

Comparisons were made of the knowledge acquired by the two groups and various sub-groups using a post-test pre-test technique. The pre-test reliability was determined using a Kuder Richardson Reliability Test and the coefficient was found to be 0.89.

Analysis of covariance was used to provide adjusted mean post-test scores for testing of hypotheses numbers 1, 2, 3, 4, 5 and 7. The variate was the post-test score while the covariates were the pre-test score and ESS score. The ESS scores were randomly distributed between the two sections and therefore should provide no bias in the final results. Suggestions for future use of the ESS data will be made in Chapter V.

A more complete set of data for each covariance program is provided in Appendix I. The information includes the covariance table, the list of means, adjusted means, adjusted standard errors for each, and a table of coefficients, standard errors, and computed t values.

The covariance results for H_o 1 may be seen in Table XIII.

TABLE XIII

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-TEST SCORES

	Analysis of Covariance			
Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	1	5.32	5.32	0.502
Error	203	2151.14	10.60	

*Difference for testing adjusted treatment means.

The null hypothesis was:

H_o 1: There is no significant difference (0.05 level of confidence) in the knowledge gained by students in the LD Group and those in the PDI Group, as measured by a pre-test and post-test administered to both groups.

The computed $F(1,203) = .50$ when compared with a tabulated $F_{0.05}(1,200) = 3.89$ clearly indicates acceptance of the null hypothesis.

Additional comparisons of mean adjusted post-test scores were made when the two groups (LD and PDI) were separated by college and then by class. The covariance results are shown in Table XIV for separation by college.

TABLE XIV

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-TEST SCORES WHEN DIVIDED BY COLLEGE

	Analysis of Covariance			
Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	5	183.10	36.17	3.69
Error	199	1973.37	9.92	

*Difference for testing adjusted treatment means

The separation by college F value of F(5,199) = 3.70 compared with a tabulated F value of $F_{0.05}(5,200) = 2.26$ shows that there is a significant difference in adjusted mean post-test scores.

A t-comparison of pairs of mean adjusted post-test scores, however, revealed significant differences only between the Agriculture, Arts and Sciences, and Other Groups within the PDI section but not between the LD and PDI Groups. The mean adjusted post-test scores are shown in Table XV.

TABLE XV

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

Group	College	Treatment Mean	Adjusted Mean	SE Adjusted
LD	Agriculture	17.48	17.84	0.42
	Arts & Sciences	18.41	18.63	0.47
	Other*	19.30	19.44	1.00

TABLE XV (Continued)

Group	College	Treatment Mean	Adjusted Mean	SE Adjusted
PDI	Agriculture	16.35	16.73	0.66
	Arts & Sciences	19.67	18.89	0.45
	Other	20.56	20.63	0.79

*Other includes Business, Education, Home Economics

The second hypothesis was:

H_o2: There is no significant difference (0.05 level of confidence) in the knowledge gained by the LD and PDI students enrolled in the various colleges. This hypothesis will be accepted on the basis of information in Tables XIV and XV.

The third hypothesis involved separation by class and the covariance results are shown in Table XVI.

TABLE XVI

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-TEST SCORES WHEN DIVIDED BY CLASS

	Analysis of Covariance			
Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	7	158.64	22.66	2.24
Error	197	1997.83	10.14	

*Difference for testing adjusted treatment means.

The separation by class F value for the two groups $F(7,197) = 2.23$ when compared with an F tabulated value of $F_{0.05}(7,200) = 2.05$ shows a minimal significant difference between the adjusted mean post-test scores. However, the number of persons in some of the classes is so small that no attempt will be made to claim a general pattern of significance.

The third hypothesis was:

H_o 3: There is no significant difference (0.05 level of confidence) in the knowledge gained by the LD and PDI students of different class levels.

This hypothesis was accepted although data collected over a number of semesters might yield some general pattern as the number of people in each group became great enough to allow more adequate comparisons.

The fourth and fifth hypotheses deal with the influence of high school and college mathematics and science courses on the students' learning as indicated by their mean post-test scores.

H_o 4: There is no significant difference (0.05 level of confidence) in the knowledge acquired by LD and PDI students having significantly different high school mathematics and science preparation.

The courses involved in testing the hypothesis were geometry, trigonometry, general science, chemistry and physics. The student divisions were based on whether the student had had none, one, two, three, four or all five of these courses. The covariance results are shown in Table XVII.

TABLE XVII

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-TEST SCORES WHEN DIVIDED BY HIGH SCHOOL SCIENCE AND MATHEMATICS COURSE BACKGROUND

Source	Analysis of Covariance Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	11	155.17	14.11	1.36
Error	193	2001.30	10.37	

*Difference for testing adjusted treatment means.

The calculated F ratio of F(11,193) = 1.36 is much smaller than the tabulated F(11,200) = 1.83. Therefore, H_o 4 is accepted. High school course background is of little influence in Descriptive Physics, in terms of student test performance.

The hypothesis relating to college course background was:

H_o 5: There is no significant difference (0.05 level of confidence) in the knowledge gained by the LD and PDI students with different background in college, algebra and chemistry.

The covariance analysis dealing with this hypotheses is given in Table XVIII.

TABLE XVIII

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-TEST SCORES WHEN DIVIDED BY COLLEGE MATHEMTAICS AND SCIENCE BACKGROUND

Source	Analysis of Covariance Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	197	2096.92	10.65	0.80

TABLE XVIII (Continued)

Source	Analysis of Covariance Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Error	7	59.55	8.51	

*Difference for testing adjusted treatment means.

A tabulated F value of $F(7,200) = 2.05$ compared with a calculated F ratio of $F(7,197) = 0.80$ shows that there is no difference in the mean adjusted post-test scores for persons with differing college algebra and chemistry course backgrounds. H_o 5 is accepted. Again the course offered no advantage to students with these courses in their background.

Attitude Comparisons

Analysis of variance was used to compare the mean attitude scores of the two Groups. The hypothesis to be tested was:

H_o 6: There is no significant difference (0.05 level of confidence) in the attitudes toward the course expressed by those students in the LD Group and those in the PDI Group, as measured by an attitude questionnaire administered to both groups at the end of the semester.

The AOV summary is shown in Table XIX. The F ratio value of 26.85 as compared with $F_{0.05}$ tabulated value of 6.67 indicated a major difference in the mean Attitude Measure Scores of the two Groups and caused rejection of the hypothesis H_o 2.

TABLE XIX

ATTITUDE SCORE TOTAL GROUP COMPARISON AOV TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio	$F_{0.01}$ (1,200)
Treatments	1	3790.51	3790.51	26.85	6.76
Error	207	29228.25	141.20		

When these two groups were further divided by college and by class, statistically significant differences in mean attitude scores were observed. See Table XX for division by college and Table XXI for division by class. The division by college F ratio was 5.96 and exceeded a tabulated value of $F_{0.05}(5,200) = 2.26$. The division by class F ratio was 2.35 and exceeded a tabulated value of $F_{0.05}(22,150) = 1.61$.

TABLE XX

ATTITUDE SCORE DIVISION BY COLLEGE AOV TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio	$F_{0.05}$ (5,200)
Treatment	5	4226.92	845.38	5.96	2.26
Error	203	28792.00	141.83		

TABLE XXI

ATTITUDE SCORE DIVISION BY CLASS AOV TABLE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio	$F_{0.05}$ (22,150)
Treatment	22	7202.13	327.37	2.35	1.61
Error	186	25816.85	138.80		

Hypotheses were not originally proposed for division by college and by class. The significant differences in Mean Attitude scores, however, warrant a more detailed inspection.

This more detailed inspection of student attitude differences was carried out by using a t comparison of the mean attitude scores of each group on each question. The results are shown in Table XXII.

Statistically significant differences (0.05 level of confidence) are indicated with an asterisk by the t value. The F ratio indicated in this table is the F test of homogeneity of variance and values less than $F_{0.05}(100,100) = 1.39$ allow the use of pooled variance t tests for comparison of means. This value is exceeded in six cases namely in questions 6, 8, 10, 12, 17 and 20. The differences in mean scores in statements 6, 10, 12 and 20 are so great that there is no difficulty with non homogeneity of variance. The F value in 17 still indicates homogeneity of variance at the 0.01 level of confidence which leaves only number 8 unresolved. This investigator believes that the general homogeneity of variance among the majority of questions will allow t comparison of the mean responses to question 8. The discussion of the implication of these differences on the study will be given in Chapter V.

Figure 2 will provide a more graphic comparison of the mean scores

TABLE XXII

T COMPARISON OF MEAN ATTITUDE SCORES OF THE LD VS PDI GROUPS

Question	Type	Group	Mean Score	Standard Deviation	F Ratio	Degrees of Freedom	t Score
1	+	LD	2.31	1.44			
		PDI	2.85	1.48	1.05	209	2.65*
2	+	LD	3.20	1.29			
		PDI	4.11	1.11	1.39	210	5.46*
3	-	LD	3.09	1.33			
		PDI	3.43	1.16	1.31	210	1.93
4	-	LD	3.85	1.24			
		PDI	3.88	1.24	1.00	208	0.77
5	+	LD	3.18	1.34			
		PDI	3.47	1.26	1.15	210	1.64
6	-	LD	3.74	1.32			
		PDI	4.37	1.04	1.61	209	3.75*
7	+	LD	3.93	1.14			
		PDI	4.32	1.02	1.25	209	2.60*
8	-	LD	4.22	1.04			
		PDI	4.55	0.80	1.69	210	2.52*
9	-	LD	4.25	1.05			
		PDI	4.47	0.97	1.17	210	1.63
10	-	LD	3.01	1.31			
		PDI	4.20	1.10	1.43	210	7.06*
11	-	LD	3.92	1.19			
		PDI	4.19	1.07	1.26	210	1.71*
12	+	LD	2.97	1.38			
		PDI	3.83	1.15	1.43	209	4.76*
13	+	LD	4.04	1.19			
		PDI	4.23	1.16	1.05	210	1.13
14	-	LD	4.31	1.01			
		PDI	4.30	1.08	1.15	210	0.07
15	-	LD	3.78	1.34			
		PDI	3.94	1.23	1.18	210	0.86

TABLE XXII (Continued)

Question	Type	Group	Mean Score	Standard Deviation	F Ratio	Degrees of Freedom	t Score
16	-	LD	3.63	1.29			
		PDI	4.05	1.17	1.21	209	2.48*
17	+	LD	3.61	1.20			
		PDI	3.92	0.99	1.47	208	2.05*
18	+	LD	4.06	0.99			
		PDI	4.02	1.06	1.16	208	0.27
19	-	LD	3.19	1.33			
		PDI	3.24	1.22	1.19	210	0.24
20	-	LD	3.57	1.19			
		PDI	4.38	0.83	2.04	210	5.55*
21	+	LD	3.78	1.17			
		PDI	4.30	0.84	1.19	210	3.67*

*Indicates a significant difference at the 0.05 level of confidence.

Figure 2. Attitude Statements

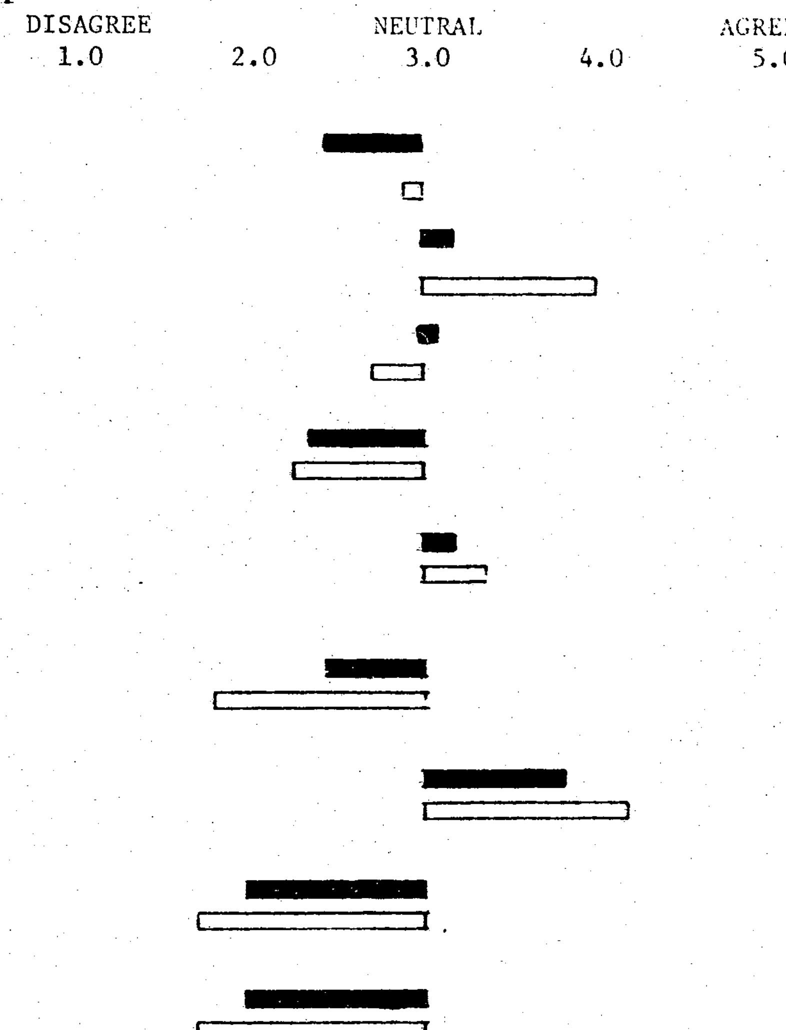
Lecture Demonstration Group Mean Response.

Presentation, Discussion, Interaction Group Mean Response.

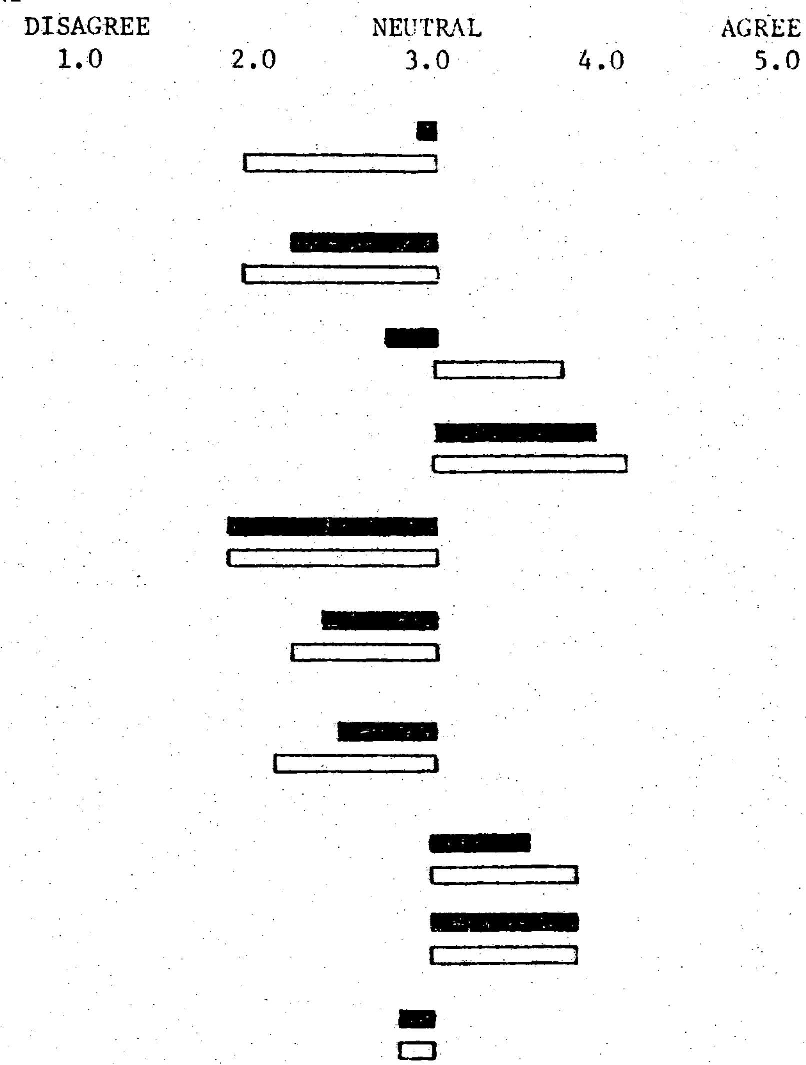
* Indicates a statistically significant difference in response of the LD and PDI Group.

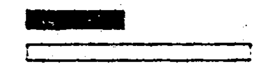
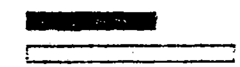
+,- Indicates a positive or a negative statement.

	STATEMENT TYPE
1. Had the course not been required, I would have* signed up anyway	+
2. I would recommend this course to friends as a* general education requirement.	+
3. In comparison with other general studies requirements, physics is much more difficult.	-
4. Homework was of no relevance to the course.	-
5. I expect that the study of physics will help me in other courses later in my career.	+
6. I came into the course expecting little, and* was not disappointed.	-
7. Even though I am reluctant to admit it, the* course has been interesting.	+
8. This course could be understood only by the* brightest student.	-
9. I have seen no value in this subject.	-



	STATEMENT TYPE
10. I believe that more than 60% of the students* disliked the subject.	-
11. If this course were not required, there would* be no enrollment.	+
12. I believe this course would benefit all* college students.	+
13. Ignoring my own scores, I believe the testing program was fair.	+
14. This course involved more rote memorization than thinking.	-
15. A good knowledge of mathematics was needed to follow most of the physics taught.	-
16. It was obvious that well prepared science* students were in the mind of the persons designing this course.	-
17. Doing my homework helped greatly in my under-* standing the material.	+
18. This was a good textbook.	+
19. More questions and problems should have been assigned and discussed.	-



	STATEMENT TYPE	DISAGREE 1.0	2.0	NEUTRAL 3.0	4.0	AGREE 5.0
20. Critical thinking was encouraged in the classroom.*	+					
21. This course forced me to think.*	+					

associated with each of the questions. The mean scores have been translated into levels of agreement and disagreement, keeping in mind whether the question was a positive one or a negative one. Two examples would be question 1 and question 6.

Question 1 is a positive question indicating that a favorable response would conform to one of the goals of the course. Scores of 2.31 for the LD Group and 2.85 for the PDI Group indicate disagreement with this positive statement. Subtracting these scores from 3, which would be a neutral response, yields the level of disagreement for each group. Ideally both groups, had the course not been one just required for their degree, would have indicated a willingness to sign up anyway. In this case the PDI Group disagreed to a lesser extent than the LD Group which in a devious fashion is an advantage in terms of the study.

In question 6 which is a negative question a great deal of disagreement by both groups is shown. Agreement with this question would have been undesirable for either group. Again the PDI Group disagrees more strongly indicating an advantage for the PDI Group in the attitude comparison.

In summary, there were twelve statistically significant differences in response to the twenty one attitude questions or statements. In each case the difference in response favored the PDI Group. There were a number of questions such as quality of textbook, relevance of homework, value of this subject, etc., for which there was no statistical difference in response. These questions were generally ones which did not depend on the teaching approach used and should not have elicited differing responses.

There is a very strong advantage shown in the attitude of the PDI

Group toward the course, not only statistically significant as shown by analysis of variance and t comparisons but by virtue of careful reading of the individual questions.

The last hypothesis represents an attempt to detect any relationship between the gender of the persons in the two groups and their post-test scores. Analysis of covariance was again used and the results are shown in Table XXIII.

The F ratio of 2.42 is less than the tabulated value of $F_{0.05}(3,200) = 2.65$. This lead to the acceptance of H_o 6.

H_o 6: There is no statistically significant difference in the adjusted mean post-test scores of the LD vs PDI Group when divided into males and females.

TABLE XXIII

COMPARISON OF LD VS PSI ADJUSTED MEAN POST-TEST SCORES WHEN DIVIDED BY MALE AND FEMALE

	Analysis of Covariance			
Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	3	75.28	25.09	2.42
Error	201	2081.19	10.35	

*Difference for testing adjusted treatment means.

A final comparison of the LD vs PDI Groups can be made in terms of outside help sought. No hypothesis was formulated with respect to this factor, but a comparison can be given. A tally of the number of students visiting the two instructors was kept. The results were 47 visits by members of the LD Group and 82 visits by members of the somewhat smaller PDI Group.

The original scores used in the analysis of covariance comparison of post-test scores are given in Appendix G. The original data used in the analysis of variance of attitude scores are provided in Appendix H.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The objective of this study was to develop an approach to teaching an introductory physics course by seeking the guidance of educational psychology and its understanding of the teaching-learning process.

The model chosen was the A. D. Woodruff (40) cybernetic model of the Behaving and Learning Cycle. Teaching, according to Woodruff, involves gaining access to the Behaving and Learning Cycle using symbolic and verbal processes of interaction with the student. The cycle exists within the student and is a closed loop. If the teacher can gain access through symbolic and verbal processes, he can guide the internal manipulation of conceptual processes, help the student in decision making, aid the student in trial of learned concepts in realistic situations, and assist in the interpretation of feedback from those trials.

Of these ~~many~~ processes, Woodruff suggested that the doing or acting stage (also called validation or shaping up) was most often missing from instruction, and that this is where feelings become associated with objects, processes, or concepts.

The teaching approach the chosen for Description Physics involved providing regular opportunities for the shaping up or validation process to occur. This was accomplished by briefly presenting the topic or concept, providing some discussion or response to student questions, and then raising a question to which the student must respond on the basis of his current understandings of the concepts involved. Where possible such questions were posed using demonstration apparatus. This request to the student required an adjustive act on his part. He might look at the apparatus again, reinterpret his own ideas, reevaluate class discussion but finally he had to commit himself to a proposed solution by vote. Feeling reactions are associated with this trial stage of learning.

This model using the suggestion of John Fowler (20) should, since it is based on existing theory, allow determination of hypotheses to be tested for a simple yes-no effect. The major hypotheses in this study were concerned with the possibility of detecting differences in knowledge gained between the LD and PDI Groups and differences in attitudes toward the course.

Conclusions

Differences in knowledge gained were not detected but differences in attitude were present, when comparing the LD and PDI Groups. McKeachie (40), Dubin and Tareggia (13), in their surveys of studies involving comparison of teaching methods, predicted the knowledge gain null result for the reasons presented in Chapter II. Dubin and Tarreggia in the conclusion of their survey made the following observation:

> We can no longer be satisfied that there are pedagogical theories that confirm and predict the advantage of one teaching method over another. We are now convinced that the proper conceptualization of the problem ... is to build a model or models of the learning-teaching process in which pedogogy is only one input into the process, although admittedly a complex one.

In spite of the null result in knowledge gained between the LD and PDI Groups, other attempts were made to detect differences by subdividing the two major groups by college, and by class. No significant differences were detected. One reason for this, not confirmable from the design nor the data of this study, may have been the use of a multiple choice format for the pre-test and post-test. The LD Group had regular multiple choice examinations throughout the semester while the PDI Group had handouts with general questions to be answered in sentence form for most of their testing program. This may have left the PDI students unprepared for the final examination in the form used.

There were statistically significant differences (0.05 level of confidence) in knowledge gained within the PDI Group when mean adjusted post-test scores were compared. The Agriculture students' mean score was 16.7, the Arts and Sciences students' mean score was 18.9 and the Other students' mean score was 20.6. A claim that each group responds differently to the PDI approach could be made, and if the goal of the study had been to detect differences among students enrolled in the various colleges, then the Business, Education, and Home Economics students out performed the others. The number of students in the three groups were: Agriculture, 23; Arts and Sciences, 54; and Other, 16. Final judgement on this question should be made only after multiple applications of the PDI teaching approach. This represents a point for further study.

A formal attempt to engender attitude and feeling responses was a major feature of the PDI teaching strategy. The measurement of the attitudes of the students toward the course at the end of the semester showed a marked difference between the two groups. The AOV comparison of the total group attitude scores had an F ratio of 26.85 compared with a tabulated F value of $F_{0.01}$(1,200_ = 6.76. The AOV comparison of the two groups divided into colleges had an F ratio of 5.96 compared with a tabulated $F_{0.01}(5,200) = 3.11$. Division by class after division by group and then college showed statistically significant differences in means but the number of students in some of the classes was too small to allow any thing but speculation about such differences.

The most meaningful information about attitude differences comes from the student's response to the 21 statements. These were phrased in such a way as to reflect the student's feeling toward the various facets of the course.

The statements (see Figure 2, Chapter IV) are identified as being positive or negative. If student's attitudes toward the course are positive then all + statements should be accompanied by levels of agreement and all - statements by levels of disagreement.

Of the 10 positive statements 8 showed levels of agreement. One, involving signing up had the course not been required (No. 1) showed levels of disagreement for both groups, with lesser disagreement exhibited by the PDI Groups. The remaining statement, dealing with a feeling that the course would be of benefit to all college students (No. 12), showed disagreement on the part of the LD Group but agreement by the PDI Group. This is an interesting paradox. Neither group would really be willing to sign up if the course were not required but the PDI Group did feel that the course would be of benefit to all college students whereas the LD Group did not. Each would recommend the course to friends (No. 2), but the PDI students were much more positive in this response.

Of the 11 negative statements all elicited disagreement. The strongest disagreements were associated with the statement suggesting that this course could be understood by only the brightest student (No. 8), and the statement "I have seen no value in this subject." (No. 9). The statement, "I came into the course expecting little and was not disappointed," (No. 6) elicited a much stronger disagreement from the PDI Group than the LD Group. The negative statement reflecting the greatest difference in response between the LD and PDI Groups was "I believe that more than 60% of the students dislike the subject," (No. 10). The PDI students disagreed while the LD students were neutral.

There were a number of the statements for which the two groups showed no statistically significant difference in response. These statements dealt with the difficulty of the course compared with other general studies requirements (No. 3), homework (No. 4), expected contribution of physics in other courses (No. 5), value of the subject (No. 9), fairness of the testing program (No. 13), quality of textbook (No. 18), etc. These questions for the most part related to factors not associated with the different teaching procedures and had not been expected to yield disagreement between the two groups.

In summary, both groups exhibited positive attitudes toward Descriptive Physics. The LD Group had a mean attitude score of 75.29, the PDI Group 83.87. On a scale ranging from 21, which would be a totally negative response, to 105 which would be a completely positive response, both values are above the theoretical midpoint value of 63. Edwards (17) warns against assuming that the arithmetic midpoint is in fact the midpoint on the attitude continuum, but both values are sufficiently above 63 to be considered positive responses.

The following conclusions result from this study:

1. There were no detectable differences in knowledge gained when comparing the LD and PDI Groups.

2. There was a strong statistically significant (0.01 level of confidence) difference in the attitude of the students toward Descriptive Physics, with the PDI exhibiting a more positive response.

The theoretical model chosen as a guide for the teaching procedures allowed the prediction that there should be greater feeling and more active attitude development in the experimental group and this apparently occurred.

3. There was no detectable difference in mean adjusted post-test scores of students with differing backgrounds in college and high school mathematics and science.

In the General Information for Physics 1014 sheet, given each student at the beginning of the semester, the suggestion was made that "Students are specifically assured that failure to enroll in advanced sciences or mathematics at the high school level does not represent any particular obstacle to successful completion of the course." Results of the study validate this assurance.

4. In a like manner, this study has shown that there is no advantage yielded to either males or females, by either approach used. Comparison of mean adjusted post-test scores showed no statistically significant differences.

Recommendations

1. This same approach should be used over a number of semesters to gain large enough population in some of the categories (Education,

Business, Seniors, Home Economics) to provide better statistical comparison of both knowledge and attitude mean scores.

2. Multiple use of this same approach would allow development of teaching or questioning apparatus and allow refinement of the model for the teaching of introductory physics.

3. Statistical procedures such as multiple covariance, may again be used with the addition of more covariates such as ACT Scores, to allow greater sensitivity in the measurement of knowledge differences.

4. In this study much demographic information was gathered from the students, as well as pre-test, and post-test and E.S.S. The use of factorial analysis would enable the researcher to look for interaction between some of these variables. This level of analysis may be required to detect significant differences in cognitive gains.

5. The achievement of an improved attitude toward introductory physics in a group of students, most of whom are required to take the course, is an important step.

The results of this study would indicate the advantage of trying this approach to others who have responsibility for introductory physics courses, although it is recognized that the approach requires much planning and cannot be undertaken lightly.

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APPENDIX A

GENERAL INFORMATION SHEETS

Instructor: Dr. D. L. Rutledge, Office B-14 (Assisted by John Layman, Office B-57)

Text: Ballif & Dibble, Conceptual Physics. This, we believe, will prove to be an excellent text. The selection and ordering of topics covered matches the instructors' interests closely and it is written with an appropriate scientific vocabulary and mathematical content. This is the only reading material to be assigned in the course and the student's first responsibility is to study it diligently.

Objectives: Our objectives in Physics 1014 are essentially the same as those of the authors as set forth in the preface. We refer the student to this material as a first reading assignment.

Prerequisites: There are no prerequisites to the course other than a genuine interest in the subject matter. Students are specifically assured that failure to enroll in advanced sciences or mathematics at the high school level does not represent any particular obstacle to successful completion of the course.

Mathematics: Mathematics has long been the shorthand of the physical sciences and is rapidly becoming more important in both the social & biological sciences. The mathematics of this course will consist of the basic principles and operations of high school algebra. One of our objectives will be to help the student reacquire any lost competence in this area. We will, however, make every attempt in the classroom and during testing to distinguish between an understanding of the basic principles of physics and their expression in mathematical form.

Class Notes: We assume that the student will study the textbook diligently and therefore much of the class time will be devoted to illustrating and giving detailed applications of the principles set forth in the text. Since many of the illustrations which we provide will not be available in the text, the importance of a good set of classnotes cannot be overemphasized.

Homework: Homew rk, in the form of questions and simple problems, will be assigned regularly. Due to the size of the class and the limited grading help available these will not, in general, be collected for grading. They will, however, serve to illustrate basic concepts, to provide experience in the application of these concepts, and to uncover areas where further discussion and study are required. Students are urged to complete each assignment promptly, to keep a complete written record of such work, and to raise questions immediately when any assignment cannot be completed. The hourly examinations will draw heavily on these assignments and it is possible that class notes and problem work will be available for the student's use during the exam period.

Attendance: Attendance will not be used as a factor in determining grades but class attendance is considered essential to proper assimilation of the subject matter and will be checked regularly. Students missing class unnecessarily should not expect individual instruction over the work missed. To facilitate checking roll, a seating chart will be prepared and students are requested to occupy the assigned seat throughout the semester.

Evaluation and Grading: Four one-hour exams will be used to establishe the course grade. Content and format of each exam will be announced well ahead of time. The letter grade for each student will be determined on each exam using standard statistical procedures. However, it is our hope that no student who attends conscientiously and works industriously will receive an unsatisfactory grade in the course. A comprehensive examination will be given during finals week.

NOTE: No Make-Up exams will be scheduled. If a student misses one of the regular exams due to circumstances beyond his control, the comprehensive final will be assigned double weight in arriving at the course grade.

Office Hours: Physics cannot, in general, be learned in isolation. Full understanding comes only after considerable communication and argument between student and teacher. You are encouraged to raise questions in class, to take exception to statements made in the text or by instructors, to request further clarification, and to stop by after class for additional conversation. To facilitate such an interplay we are setting aside approximately two hours each day in which one of the instructors will be available to help you in any way we can. The hours have purposely been set in the afternoon when many students are free of classes. Homework assignments are designed to help you learn physics. Frequently the best way to do this is to arrive at tentative answers or solutions and

M W Th F   1:30 to 2:30
M T W Th   3:30 to 4:30

You are also free to consult us at any other mutually convenient time.

GENERAL INFORMATION FOR PHYSICS 1014.2

Instructor: John Layman, Office B-57 (Assisted by D. L. Rutledge, Office B-14)

Text: Ballif & Dibble, Conceptual Physics. This, we believe, will prove to be an excellent text. The selection and ordering of topics covered matches the instructors' interests closely and it is written with an appropriate scientific vocabulary and mathematical content. This is the only reading material to be assigned in the course and the student's first responsibility is to study it diligently.

Objectives: Our objectives in Physics 1014 are essentially the same as those of the authors as set forth in the preface. We refer the student to this material as a first reading assignment.

Prerequisites: There are no prerequisites to the course other than a genuine interest in the subject matter. Students are specifically assured that failure to enroll in advanced sciences or mathematics at the high school level does not represent any particular obstacle to successful completion of the course.

Mathematics: Mathematics has long been the shorthand of the physical sciences and is rapidly becoming more important in both the social and biological sciences. The mathematics of this course will consist of the basic principles and operations of high school algebra. One of our objectives will be to help the student reacquire any lost competence in this area. We will, however, make every attempt in the classroom and during testing to distinguish between an understanding of the basic principles of physics and their expression in mathematical form.

Class Notes: We assume that the student will study the textbook diligently and therefore much of the class time will be devoted to illustrating and giving detailed applications of the principles set forth in the text. Since many of the illustrations which we provide will not be available in the text, the importance of a good set of classnotes cannot be overemphasized.

Homework: Homework, in the form of questions and simple problems, will be assigned regularly. These assignments will serve to illustrate basic concepts, provide experience in their application, and uncover areas where further discussion and study are required. Students are urged to complete each assignment promptly, to keep a complete written record of such work, and to raise questions immediately when any assignment cannot be completed. Pace of the course and the direction taken by the instructor will depend significantly on students' response to such items. Thus it is important that you tackle an assignment on time in order that you can affect subsequent instruction. Homework will, on occasion, be collected for grading.

Evaluation and Grading: No regular examinations will be given in the course. Instead the grade will be established on the basis of a series of 30 to 40 homework papers and in-class quizes. These will be evaluated on a point basis with each student expected to keep track of his cumulative point record during the term. The point distribution for the entire class will be posted weekly with <u>tentative</u> letter grade markers so that each individual can determine his or her standing in the class. No provision will be made to make up missed homework or quizzes. It is assumed that class attendance will be consistent and the number of papers will be such that one or two absences should not affect the grade. Special consideration will be made for students who have prolonged absences due to serious illness provided that the circumstances are made clear to us promptly at the time of the absences.

A comprehensive examination will be given during finals week and will count one-fourth in the determination of the course grade.

Office Hours: Physics cannot, in general, be learned in isolation. Full understanding comes only after considerable communication and argument between student and teacher. You are encouraged to raise questions in class, to take exception to statements made in the text or by instructors, to request further clarification, and to stop by after class for additional conversation. To facilitate such an interplay we are setting aside approximately two hours each day in which one of the instructors will be available to help you in any way we can. The hours have purposely been set in the afternoon when many students are free of classes. Homework assignments are designed to help you learn physics. Frequently the best way to do this is to arrive at tentative answers or solutions and then to "try them out" on your instructor. We recommend such an approach and will be available in Room B-57 (directly below the lecture hall) according to the following schedule:

then to "try them out" on your instructor. We recommend such an approach and will be available in Room B-57 (directly below the lecture hall) according to the following schedule:

M W Th F	1:30 to 2:30
M T W Th	3:30 to 4:30

You are also free to consult us at any other mutually convenient time.

APPENDIX B

QUESTIONNAIRE

Name ______________________ Student No. ______ 1,2,3 (1) Male 4
Last First Middle (2) Female

To Respond - <u>Circle the correct answer</u>

Class (1) Fr. (2) So. (3) Jr. (4) Sr. 5

College (1) Agriculture (2) Arts and Sciences (3) Business (4) Education (5) Engineering (6) Home Economics (7) Technical Institute (8) Unclassified 6

Size of your high school graduating class? 7

(1) 0-50 (2) 50-100 (3) 100-200 (4) 200-300 (5) 300-500 (6) 500+

Why are you taking this course? 8

(1) It is required (2) As an elective

Who recommended this course? 9

(1) Your college advisor (2) Other students (3) High School teacher (4) Parents (5) Self

Who made the final decision? 10

(1) Advisor (2) Self (3) Self and Advisor

Which of these high school courses have you taken? 11-17

(11) First year Algebra (12) Second year Algebra
(13) Geometry (14) Trigonometry (15) General Science
(16) Chemistry (17) Physics

Which of these college courses have you taken? 18-23

(18) College Algebra (19) Solid Geometry (20) Trigonometry
(21) Calculus (22) Advanced Calculus (23) General Chemistry

APPENDIX C

PRE-TEST

1. Combine and simplify the following fraction: $\frac{1}{4} + \frac{1}{6} - \frac{1}{3} =$

   (1) $\frac{3}{7}$ (2) $\frac{2}{3}$ (3) $\frac{12}{5}$ (4) $\frac{4}{6}$ (5) $\frac{1}{12}$

2. Given $3n + 4 = 16$. Solve for n.

   (1) 4 (2) $\frac{20}{3}$ (3) $\frac{16}{7}$ (4) $\frac{1}{4}$ (5) None of the above values

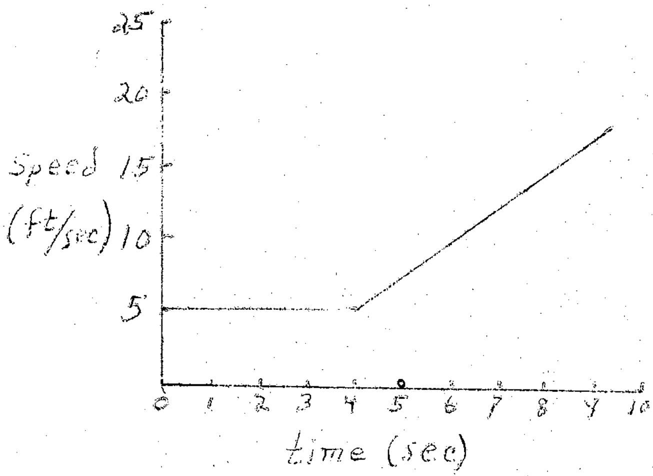
3. Given $5(x - 2) = 40$. Solve for x.

   (1) $\frac{38}{5}$ (2) 5 (3) 10 (4) 6 (5) None of the above

4. Write the number 0.25 in power of 10 notation.

   (1) 25×10^2 (2) 2.5×10^{-1} (3) 2.5×10^1 (4) 2.5×10^3

   (5) None of the above



The area under the curve between 0 and 3 seconds is:

(1) 45

(2) 45 ft.

(3) 15 ft.

(4) 5 ft.

(5) None of the above

6. Newton's first law of motion is:

   (1) As the mass of an object increases so must its velocity.

   (2) Objects traveling in a circle at <u>constant</u> speed are accelerating.

(3) An object at rest tends to remain at rest, while an object in motion tends to remain in motion in a straight line, unless acted upon by an outside force.

(4) For every action there is an equal but opposite reaction.

(5) As the temperature of a confined gas rises its pressure must also rise.

7. A man walks 3 miles East then turns and walks 4 miles North. The magnitude of his displacement at this point is?

(1) 7 (2) 7 miles (3) 12 miles (4) 5 miles (5) 5

8. Newton's Second Law of Motion is given in the form F = ma. If you exert a force of 50 lbs on an object and its acceleration is measured as 10 ft/sec^2, What was the object's mass?

(1) 500 (2) 5 slugs (3) $\frac{2}{10}$ slugs (4) 5 (5) 5 Kg.

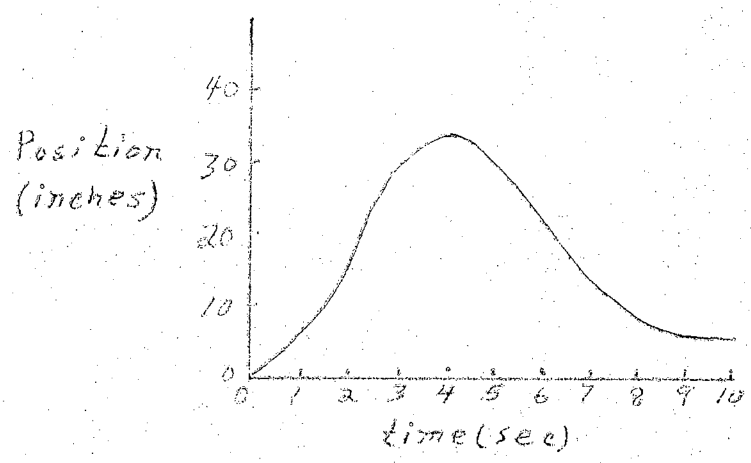
9. The correct expression for momentum is:

(1) ma (2) $\frac{1}{2}mv^2$ (3) $\frac{m_1m_2}{r^2}$ (4) mv (5) $k\frac{qq}{r^2}$

10. Mass is:

(1) The weight of an object; (2) The weight of an object divided by its volume; (3) That property which may be measured by exerting a known force on an object, measuring its acceleration, and taking a ratio of these two; (4) Dependent upon an object's position in the universe; (5) Dependent on an object's composition?

This graph is to be used in the next three problems (11, 12, 13)



11. This is a graph of the position of a body at various times as it moves in a straight line. At what time does the body have maximum speed?

(1) 1 sec. (2) 2 sec. (3) 3 sec. (4) 4 sec. (5) 5 sec.

12. At what time is the speed of the object zero?

(1) 1 sec. (2) 2 sec. (3) 3 sec. (4) 4 sec. (5) 5 sec.

13. What is the object's approximate speed at t = 2 sec?

(1) 1 in/sec. (2) 5 in/sec. (3) 10 (4) 30 in/sec. (5) 60

14. Gravity is the force exerted between an object and the earth. As an object moves toward the earth from outer space its weight (the attraction between the earth and the object) increases. The object's mass will: (1) decrease, (2) increase, (3) remain the same, (4) this has no relevance to gravitational experiments, (5) be changed to energy.

15. Planet X is more massive and of smaller radius than the earth. Will your weight on "X" be: (1) greater, (2) less, (3) same since your mass does not change, (4) not discussable since it is a different planet, (5) exactly doubled.

16. The Bernoulli effect has to do with: (1) pressure of light on the earth's surface, (2) weight of fluids, (3) pressure in moving fluids, (4) pressure in a high temperature gas, (5) the secondary school at Bernoulli, Oklahoma.

17. A sled is traveling in a straight line at constant speed on a frictionless surface. Which is the correct statement about the forces acting on the sled:

(1) There are no forces, (2) There is a force in the direction of motion keeping it moving, (3) There is no way of making judgement on the forces, (4) The sum of the forces must be zero, (5) There must be a force to counteract friction.

18. If density is defined as mass per unit volume ($D = \frac{m}{v}$) what is the volume of an object whose mass is 50 gm and whose density is 100 gm/cm^3: (1) 5000, (2) 5000 gm^2/cm^3, (3) 0.5 cm^3, (4) 0.5, (5) 2 cm^3.

19. Which is the correct expression for gravitational potential energy:

(1) mgh, (2) $\frac{1}{2}mv^2$, (3) mv, (4) $G\frac{m_1m_2}{r^2}$, (5) $K\frac{q_1q_2}{r^2}$

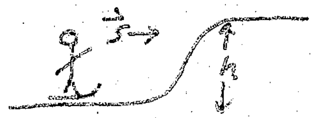
20. What would be the approximate gravitational potential energy of an object whose mass is 5 kg and whose height about the earth 10 m: (1) 20 joules, (2) 5 joules, (3) 50 joules, (4) 500 joules, (5) 1 joule.

21. You could change the period of a pendulum by:

(1) pushing it harder, (2) changing its length, (3) changing its mass, (4) changing the kind of support used, (5) none of these methods.

22. If a 50 kg skier traveling 20 m/s approaches a slope, and if we neglect friction, how high will he rise?

(1) 1 m, (2) 10 m, (3) 20 m,
(4) 40 m, (5) 100 m



23. If a 150 lb man approaches a slope traveling 8 ft/sec, again neglecting friction, how high will he rise:

(1) 1 ft, (2) 5 ft, (3) 10 ft, (4) 50 ft, (5) 100 ft.

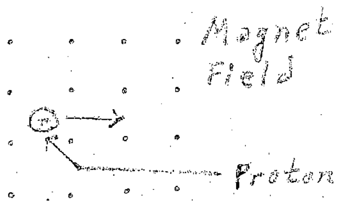
24. As an object falls freely near the surface of the earth its total energy: (1) increases as it gains speed, (2) decreases with height, (3) increases due to air resistance, (4) does not enter into falling, (5) remains the same but is shared between potential and kinetic energy.

25.

Two small metallic bodies (A & B) are brought near, but not touching, a large positively charged object (C). A and B are allowed to touch each other while in the position shown, they are then separated and removed from the vicinity of C. Upon examination with an electroscope, B will be found to be:

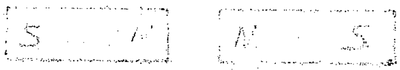
(1) uncharged, (2) positively charged, (3) negatively charged, (4) can not tell since they did not touch C.

26.



Consider a region of uniform magnetic field perpendicular to and directed out of the plane of the page. A proton (+) is traveling to the right as shown. It will experience a force: (1) perpendicular to the plane of the paper and toward the reader, (2) perpendicular to the plane of the paper and away from the reader, (3) in the plane of the paper and downward, (4) no force at all.

27.



Consider two magnets oriented as shown. What will be the nature of the force between them: (1) attractive, (2) repulsive, (3) none, (4) neutralized by having like poles together.

28. The two magnets above are pushed together so that their north poles touch. According to the theory of relativity the total mass of the system will: (1) increase, (2) decrease, (3) remain the same, (4) is not influenced by position of the two poles.

29. A device for storing electrical charge is: (1) a battery, (2) a generator, (3) an electrolyte, (4) a capacitor, (5) a resistor.

30. Light is believed to be: (1) a particle, (2) a wave, (3) both particle and wave, (4) neither, (5) either a particle or a wave depending upon the experiment.

APPENDIX D

EDUCATIONAL SET SCALE

We have selected several courses in which large numbers of students tend to enroll. For each course we have listed a variety of topics covered, items of information presented, and tasks to be accomplished.

Assume that you are enrolled in these courses and therefore are required to learn about each of the topics listed on the following pages.

The topics are listed in groups of three. Decide which one of the three topics in each group would interest you most and which one would interest you least. Rank the topics in each set of three indicating the extent to which each one interests you by assigning

1. to the topic that interests you MOST
2. to the topic in which you have an intermediate interest
3. to the topic that interests you LEAST

You may not omit a rank for any topic or assign the same rank to two topics within a set. Although it may sometimes be difficult for you to make a decision, it is imperative that you do so by assigning ranks of 1, 2, and 3 to the topics listed in each set.

Form 1

Examples:

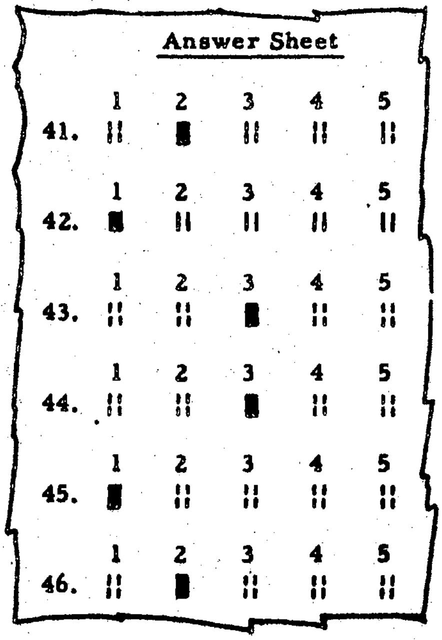
Assume you are enrolled in a GEOGRAPHY course and must learn about the following:

A. Items 41 - 43

41. The causes of earthquakes.
42. The names of the world's major oceans.
43. The distinction between anthracite and bituminous coal.

B. Items 44 - 46

44. The length of the Panama Canal.
45. The influence of terrain upon farming procedures.
46. The location of major United States timber resources.



This person has marked his answer sheet for two sets of topics. He has indicated that, of the three topics in Set A, he is most interested in 42 ("names of the world's major oceans"); least interested in 43 ("distinction between anthracite and bituminous coal"); and has an intermediate interest in 41 ("causes of earthquakes"). Of the three topics in Set B, he is most interested in 45, least interested in 44, and has an intermediate interest in 46.

Note: Although the answer sheet has 5 answer positions, you are to use only positions 1, 2, and 3 to rank the three topics in each set.

Remember also that you must rank every topic in the set and you cannot assign the same rank to any two topics.

KEY:

1 - MOST interest in this topic
2 - Intermediate interest in this topic
3 - LEAST interest in this topic

****

Assume you are enrolled in a GEOGRAPHY course and must learn about the following:

A. Items 1 - 3

1. The factors responsible for westward population migration in the U.S.
2. The names of the capitals of the European countries.
3. The names and locations of the 10 largest rivers in the world.

B. Items 4 - 6

4. The average annual per capita consumption of petroleum products in the U.S.
5. The definitions of loess, mesas, drumlins, lithosphere, playas, and biosphere.
6. Requisites for artesian well systems.

C. Items 7 - 9

7. How artesian wells are formed.
8. Forecasts about the weather to be expected in New York City during the next 48 hours from examination of a weather map.
9. The chemical composition of lava.

D. Items 10 - 12

10. The meaning of "cold," "warm," "occluded," and "cyclonic" fronts.
11. The five major world producers (in order of importance) of iron, lead, zinc, and copper.
12. The role of seaports in national economy.

E. Items 13 - 15

13. The factors considered by geologists in attempting to locate oil deposits.
14. Statistics on the average family size for each socioeconomic subgroup.
15. Population shifts in the United States during the past 50 years.

F. Items 16 - 18

16. The names of the world's major glacial areas.
17. The influence of terrain upon agricultural crops.
18. The route taken by the St. Lawrence Seaway.

(Go Right On To The Next Page)

KEY:

1 - MOST interest in this topic
2 - Intermediate interest in this topic
3 - LEAST interest in this topic

****

Assume you are enrolled in a SOCIAL SCIENCE course and must learn about the following:

A. Items 19 - 21

19. Environment as a partial determinant of mental illness.
20. The relationship between I.Q. and scholastic success in a college or university.
21. Average ages at which children first begin to creep, walk, identify colors, etc.

B. Items 22 - 24

22. The difference between a psychiatrist, a psychologist, and a psychoanalyst.
23. The percentage of youngsters apprehended as juvenile delinquents who subsequently are apprehended by the law for committing a major crime.
24. The role of psychological testing in vocational guidance.

C. Items 25 - 27

25. The proportion of United States residents now over age 65.
26. The effects of caffeine upon muscular coordination.
27. The meaning of "percentile" in interpreting test results.

D. Items 28 - 30

28. The primary symptoms differentiating psychotic (insane) behavior from neurotic behavior.
29. The specific human capabilities known to deteriorate after about age 60.
30. The average incomes of various classifications of workers in the U.S. (e.g., unskilled, semiskilled, technical, professional, etc.)

E. Items 31 - 33

31. The percentage of family income that ought to be budgeted for rent, food, clothing, recreation, etc.
32. What it is that the psychoanalyst attempts to do.
33. The current divorce rate in the United States.

(Go Right On To The Next Page)

KEY:

1 - MOST interest in this topic
2 - Intermediate interest in this topic
3 - LEAST interest in this topic

****

Assume you are enrolled in a BUSINESS & ECONOMICS course and must learn about the following:

A. Items 34 - 36

34. The functions of the Securities and Exchange Commission.
35. Factors operating to diminish the size of the U.S. gold reserve.
36. Why an "easy money" policy may be unsound public policy.

B. Items 37 - 39

37. The names of the components of the "Gross National Product."
38. The meaning of an "odd lot" in stock purchases.
39. The purpose underlying agricultural price supports.

C. Items 40 - 42

40. Major events in the growth of U.S. labor unions.
41. The names of the nations constituting the "common market."
42. Factors underlying a decision to invest vs. a decision to save.

D. Items 43 - 45

43. The name of an inflationary potential in the economy which is artificially kept from registering itself in prices.
44. The relationship between disposable incomes and total expenditures for consumer goods.
45. The ways in which Federal Reserve monetary policy attempts to accomplish its goals.

E. Items 46 - 48

46. How to read entries in the stock market page of a newspaper.
47. The present established worth of an ounce of gold.
48. What is meant by a "holding company."

(Go Right On To The Next Page)

KEY:

1 - MOST interest in this topic
2 - Intermediate interest in this topic
3 - LEAST interest in this topic

****

Assume you are enrolled in a GOVERNMENT course and must learn about the following:

A. Items 49 - 51

49. The uses of international law in government.
50. The steps involved in amending the United States Constitution.
51. The functions of the Federal Communications Commission (FCC).

B. Items 52 - 54

52. The causes of the Cuban crisis.
53. The reasons for official U.S. opposition to recognizing Red China.
54. Comparative armed strength of the U.S. and Russia.

C. Items 55 - 57

55. Pros and cons of alternative solutions to U.S. housing problems.
56. Consequences of technological unification of the world.
57. A statement of the Marxist theory of history.

D. Items 58 - 60

58. The functions of the Central Intelligence Agency.
59. The estimated annual cost to the U.S. of the "cold war."
60. The pressures operating to produce European unity and disunity.

E. Items 61 - 63

61. Differences in the social and economic characteristics of midwestern republicans and democrats.
62. The limits of authority of a Justice of the Peace.
63. The names and dates of office of the U.S. presidents.

F. Items 64 - 66

64. The ways in which states are admitted to the Western State System.
65. The meaning of government to John Locke.
66. The name of the international organization conducting surveys of the world food situation.

(Go Right On To The Next Page)

KEY:

1 - MOST interest in this topic
2 - Intermediate interest in this topic
3 - LEAST interest in this topic

****

Assume you are enrolled in a NATURAL SCIENCE course and must learn about the following:

A. Items 67 - 69

67. The explanation for the fact that it is sometimes difficult to recognize voices on the telephone.
68. The distances from earth to the other planets in our galaxy.
69. The critical velocity required to escape the earth's gravitational pull.

B. Items 70 - 72

70. The names of the elements included within the "halide" group.
71. Statement of Newton's third law of motion.
72. The significance of a pH of 6.

C. Items 73 - 75

73. Formula for converting centigrade temperature readings to fahrenheit readings.
74. The difference in chemical structure between H_2O (water) and H_2O_2 (hydrogen peroxide).
75. The distinction between "anode" and "cathode."

D. Items 76 - 78

76. Chemical factors associated with transmitting neural impulses.
77. Why thrust is generated by a jet engine.
78. The chemical structure of penicillin.

E. Items 79 - 81

79. The relative conductivity of certain substances (e. g., iron, copper, zinc, wood).
80. The meaning of "specific gravity."
81. The effect of increased pressure upon the boiling point of a liquid.

(Go Right On To The Next Page)

KEY:

1 - MOST interest in this topic
2 - Intermediate interest in this topic
3 - LEAST interest in this topic

****

Assume you are enrolled in an ENGLISH course and must learn about or do the following:

A. Items 82 - 84

82. Write a report on the novel entitled 1984.
83. The names of Shakespeare's comedies.
84. The reason why Hedda Gabler (in Ibsen's Hedda Gabler) kills herself.

B. Items 85 - 87

85. The names of 10 contemporary authors and their most important works.
86. Write a biographical sketch based upon library research of any author (no longer living) of your choice.
87. The effects of 19th century American history upon the American literature of the period.

C. Items 88 - 90

88. The elements in a play that lead to its classification as a "tragedy."
89. The correct spelling for the word meaning "to pay" (i.e., is it "renumerate" or "remunerate").
90. Write a theme about the most interesting person you have ever met.

D. Items 91 - 93

91. The dates and major works of well-known poets like Whitman, Longfellow, Wordsworth, etc.
92. The role of the playwright in contemporary society.
93. The structure (i.e., number of lines, rhyming schemes, etc.) of sonnets.

APPENDIX E

ATTITUDE MEASURE

Please check the following as quickly and as candidly as possible. Responses will not be considered until after final grades are determined.

Class: (Circle One) Freshman Sophomore Junior Senior Graduate

Male Female

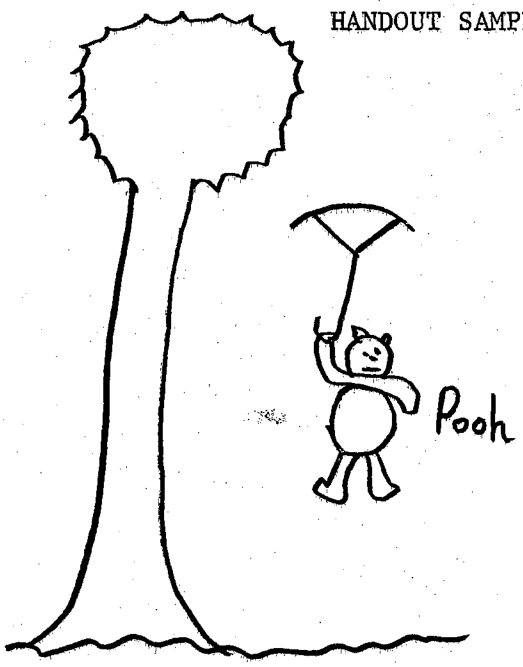
College: Agriculture Arts and Sciences Education Other

	Strongly Agree		Neutral		Disagree
Had the course not been required, I would have signed up anyway.	5	4	3	2	1
I would recommend this course to friends as a general education requirement.	5	4	3	2	1
In comparison with other general studies requirements, physics is much more difficult.	5	4	3	2	1
Homework was of no relevance to the course.	5	4	3	2	1
I expect that the study of physics will help me in other courses later in my career.	5	4	3	2	1
I came into the course expecting little, and was not disappointed.	5	4	3	2	1
Even though I am reluctant to admit it, the course has been interesting.	5	4	3	2	1
This course could be understood only by the brightest student.	5	4	3	2	1
I have seen no value in this subject.	5	4	3	2	1
I believe that more than 60% of the students disliked the subject.	5	4	3	2	1
If this course were not required, there would be no enrollment.	5	4	3	2	1
I believe this course would benefit all college students.	5	4	3	2	1
Ignoring my own scores, I believe the testing program was fair.	5	4	3	2	1

	Strongly Agree		Neutral		Disagree
This course involved more rote memorization than thinking.	5	4	3	2	1
A good knowledge of mathematics was needed to follow most of the physics taught.	5	4	3	2	1
It was obvious that well prepared science students were in the mind of the persons designing this course.	5	4	3	2	1
Doing my homework helped greatly in my understanding the material.	5	4	3	2	1
This was a good textbook.	5	4	3	2	1
More questions and problems should have been assigned and discussed.	5	4	3	2	1
Critical thinking was encouraged in the classroom.	5	4	3	2	1
This course forced me to think.	5	4	3	2	1

APPENDIX F

HANDOUT SAMPLE QUESTIONS



"Arts and Science and Newton's Laws"

1. Identify the reaction forces to the action forces listed.

    a. Umbrella's force on the air molecules.

    b. The umbrella's force upward on Pooh.

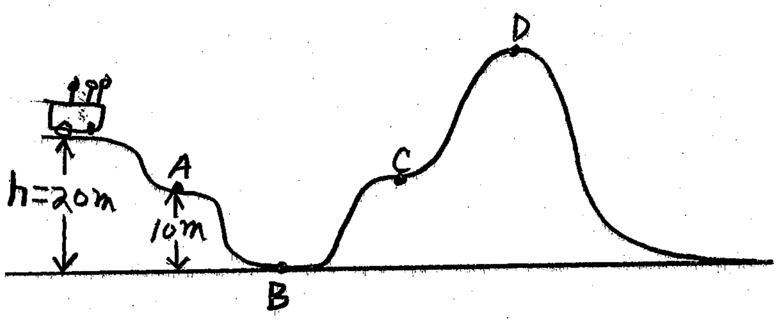
    c. Pooh's weight.

2. If Pooh is falling at a constant speed, what can be said of the forces on Pooh? Identify the forces <u>on</u> Pooh.

3. Is Pooh's momentum changing as he gets closer to the earth?

4. If Pooh's velocity is 5 m/s downward and his mass is .2 killogram, what is his momentum?

5. This is a physics style rollercoaster (frictionless of course). The vehicle is allowed to start from rest on a slight incline (no initial speed). Its mass is 100 kg. Its height at various points is given on the diagram.



(a) What is its initial energy? Show how gotten.

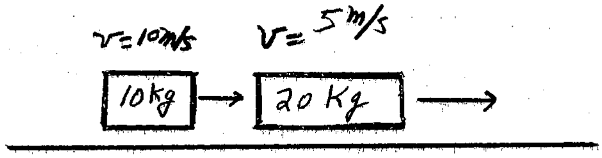
(b) What is its energy at point A? Explain carefully.

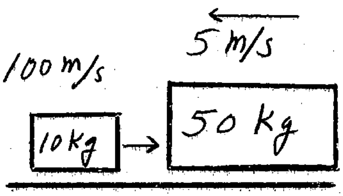
(c) I claim that its energy at point B is zero. What am I referring to?

(d) What will be the object's speed at D?

(e) What influence would friction have if it were present?

6. Two objects approach one another as shown. If upon collision they stick together, what will be the velocity of the objects?



7. 

Two objects approach one another as shown. After collision, which way will they travel if they stick together? Why?

8. How do we know that energy can be transferred from one object to another by the process of work? Explain in detail.

9. Do the earth and moon have more or less energy at present than they would have if the moon were lying on the surface of the earth but things were otherwise the same? Explain carefully.

10. Would it be possible to throw a snowball against a wall at such speed that it would entirely melt on impact? Explain in good "physics" form.

11. When a gun is fired, the momentum of the gun and bullet are approximately equal in magnitude. Why, then, is it not just as dangerous to be hit by the gun as the bullet?

12. Explain briefly what must be done to give an object a charge.

13. What is a coulomb?

14. What is an electric current?

APPENDIX G

PRE-TEST, POST-TEST, ESS SCORES

SCORES LD GROUP

Student Number	Pre-Test	Post-Test	Educational Set Scale
01	09	19	+31
02	11	16	-01
03	15	22	+21
04	13	20	+20
05	11	20	+22
06	08	18	+14
07	13	20	+15
08	08	17	+08
09	09	17	+12
10	14	23	+12
11	12	16	-06
12	10	18	+08
13	09	15	-05
14	09	20	+34
15	09	11	+10
16	06	17	+15
17	12	22	+18
18	06	24	+12
19	10	21	+00
20	07	19	+03
21	08	23	+27
22	13	16	+10
23	11	33	+13
24	05	15	+06
25	09	19	+17
26	09	17	+06
27	08	18	+06
28	11	14	+09
29	06	20	+02
30	07	13	-02
31	12	15	+00
32	05	19	+05
33	13	20	+04
34	11	18	+11
35	10	17	+21

APPENDIX G (Continued)

Student Number	Pre-Test	Post-Test	Educational Set Scale
36	17	19	-03
37	11	19	+03
38	09	13	+08
39	14	22	+41
40	09	15	-14
41	06	22	+08
42	13	19	+07
43	08	19	+16
44	14	17	-04
45	09	13	+04
46	10	22	+10
47	09	16	+12
48	12	21	+03
49	14	14	+13
50	05	12	-04
51	05	12	+04
52	14	21	+13
53	18	20	+12
54	06	15	+10
55	12	21	+12
56	05	15	-09
57	07	21	-03
58	12	20	-04
59	14	18	+16
60	15	27	-08
61	13	18	-12
62	08	17	+13
63	06	11	-07
64	08	12	-03
65	11	19	+09
66	07	25	-10
67	08	19	+22
68	13	18	-10
69	11	19	+13
70	09	17	+12
71	12	17	+04
72	08	19	+17
73	11	24	+23
74	10	16	+12
75	10	14	+11
76	11	15	+16
77	11	20	+11
78	13	16	+15
79	08	15	+01
80	10	16	+13
81	06	19	+21
82	12	15	-09

APPENDIX G (Continued)

Student Number	Pre-Test	Post-Test	Educational Set Scale
83	06	13	-11
84	11	19	+07
85	13	16	+01
86	10	18	+29
87	08	15	+39
88	09	13	+14
89	18	17	+26
90	10	15	-14
91	12	17	-01
92	08	17	+02
93	07	14	+07
94	11	17	+06
95	13	26	+02
96	10	20	-06
97	17	18	+29
98	10	16	+08
99	18	26	+19
100	09	21	+34
101	13	20	+05
102	18	25	+22
103	04	16	-11
104	15	22	+12
105	07	21	+15
106	10	19	+16
107	12	21	+01
108	12	18	+20
109	06	09	-01
110	04	13	+05
111	09	16	+17
112	15	17	-13
113	09	15	+11
114	10	18	+30

APPENDIX G (Continued)

SCORES PDI GROUP

Student Number	Pre-Test	Post-Test	Educational Set Scale
1	17	20	+17
2	09	20	+00
3	16	25	+15
4	09	21	+35
5	08	19	+14
6	08	20	+10
7	10	19	+05
8	12	17	+13
9	12	21	+11
10	07	18	+05
11	10	20	+19
12	13	18	-05
13	14	20	+21
14	13	29	+01
15	18	22	+22
16	12	22	-08
17	08	20	-07
18	13	15	+29
19	15	24	+14
20	12	21	+10
21	11	20	-05
22	13	18	+13
23	11	19	+19
24	12	20	+06
25	07	15	+10
26	12	25	+27
27	12	17	+04
28	09	14	+06
29	12	21	+18
30	10	18	+16
31	14	23	+19
32	14	12	+07
33	15	23	+22
34	13	19	+28
35	09	18	+15
36	13	26	+25
37	11	20	-04
38	11	21	-01
39	14	20	+17
40	16	18	+12
41	11	21	+21

APPENDIX G (Continued)

Student Number	Pre-Test	Post-Test	Educational Set Scale
42	14	19	+09
43	12	18	+15
44	16	23	+12
45	04	19	+00
46	13	20	-01
47	13	22	-03
48	12	18	+09
49	15	19	-01
50	14	17	+04
51	10	21	-04
52	12	15	+10
53	11	16	+06
54	14	18	+01
55	11	15	+03
56	14	18	-07
57	10	15	+11
58	07	16	+06
59	09	20	-06
60	09	18	+10
61	12	22	+23
62	11	19	+02
63	10	14	+05
64	10	15	+07
65	08	12	+02
66	08	17	+04
67	08	12	+07
68	09	09	-05
69	16	24	+04
70	16	16	+14
71	08	16	+06
72	11	21	+09
73	10	24	+17
74	10	14	+07
75	09	20	+20
76	12	21	+07
77	11	18	+11
78	11	13	+17
79	07	16	+11
80	15	18	+16
81	16	21	+32
82	13	26	+11
83	14	22	+24
84	10	14	+03
85	09	19	+14
86	10	18	+06
87	15	22	+12
88	12	18	+08

APPENDIX G (Continued)

Student Number	Pre-Test	Post-Test	Educational Set Scale
89	14	21	-08
90	16	23	+07
91	14	18	+02
92	15	22	+17
93	10	16	-14

APPENDIX H

ATTITUDE QUESTIONNAIRE SCORES

LD GROUP

Student Number	a	b	c[1]	Score
1	2	2	2	90
2	1	0	2	82
3	2	1	4	75
4	2	0	4	57
5	1	0	2	88
6	2	1	1	76
7	2	0	1	59
8	2	0	1	64
9	2	1	1	94
10	3	1	1	76
11	3	0	1	72
12	4	1	1	62
13	1	2	3	88
14	3	1	1	86
15	1	2	2	84
16	1	2	3	68
17	3	1	1	89
18	4	0	4	60
19	2	2	3	68
20	1	1	1	88
21	3	0	1	91
22	2	1	1	81
23	1	1	2	87
24	2	1	1	91
25	1	1	2	85
26	4	0	1	83
27	1	1	1	96
28	2	1	1	89
29	1	0	2	88
30	3	1	1	70
31	3	1	1	77
32	3	0	2	45
33	3	1	1	80
34	4	0	1	66
35	2	1	1	94

APPENDIX H (Continued)

Student Number	a	b	c^2	Score
36	2	1	2	89
37	3	0	2	46
38	3	1	1	60
39	4	0	3	66
40	2	0	1	77
41	4	1	1	82
42	4	1	1	79
43	3	2	2	60
44	3	2	2	84
45	2	0	1	90
46	2	2	2	89
47	4	2	3	56
48	3	1	1	61
49	1	1	1	69
50	3	0	2	82
51	4	2	2	71
52	1	1	1	62
53	3	1	1	78
54	2	2	2	66
55	3	1	1	76
56	3	0	2	84
57	3	1	1	82
58	3	2	2	71
59	2	1	2	74
60	2	2	2	98
61	2	1	2	83
62	3	0	1	52
63	2	0	1	55
64	1	0	1	84
65	2	2	4	77
66	4	1	1	79
67	2	0	1	79
68	3	0	1	82
69	4	0	2	41
70	2	1	1	75
71	1	0	0	80
72	1	1	4	82
73	2	1	1	68
74	2	1	2	80
75	2	2	2	83
76	3	1	1	90
77	1	1	2	75
78	1	2	2	76
79	3	2	1	58
80	4	1	4	67
81	2	0	2	72

APPENDIX H (Continued)

Student Number	a	b	c[1]	Score
82	2	0	3	87
83	1	0	2	85
84	4	0	2	47
85	1	0	1	86
86	2	2	2	54
87	3	0	2	56
88	1	2	2	59
89	4	0	1	77
90	3	2	2	77
91	1	1	1	75
92	4	0	1	93
93	2	1	1	76
94	2	2	2	67
95	4	1	1	75
96	1	1	2	84
97	3	1	1	94
98	3	2	2	83
99	4	1	4	82
100	1	2	2	97
101	0	0	0	87
102	3	1	1	82
103	2	0	2	85
104	3	1	2	65
105	2	0	2	95
106	1	1	1	75
107	2	1	1	55
108	3	1	1	71
109	4	1	1	45
110	2	2	2	71
111	3	0	1	61
112	3	2	2	81
113	4	0	2	79
114	4	1	1	82
115	3	1	1	66
116	1	1	1	93
117	4	1	1	78
118	2	1	2	43
119	3	0	2	69

[1]Column a, b, c indicate:

a. Class (1) Freshman, (2) Sophomore, (3) Junior, (4) Senior, (5) Graduate.

b. Sex (1) male, (2) female

c. College (1) Agriculture, (2) Arts and Sciences, (3) Other [Business, Education, Home Economics].

APPENDIX H (Continued)

ATTITUDE QUESTIONNAIRE SCORES

PDI GROUP

Student Number	a	b	c[1]	Score
1	2	2	2	61
2	1	2	2	74
3	2	1	4	76
4	1	1	1	90
5	2	1	2	73
6	4	1	2	71
7	3	2	3	78
8	2	1	2	91
9	2	0	2	84
10	4	1	2	90
11	2	0	1	87
12	2	1	2	94
13	3	1	2	84
14	1	1	2	68
15	3	1	2	89
16	2	0	2	97
17	2	1	2	83
18	2	0	3	96
19	3	0	2	92
20	1	2	2	101
21	2	0	4	73
22	2	2	2	76
23	3	0	1	89
24	3	0	2	85
25	3	1	2	82
26	1	1	1	86
27	1	1	2	71
28	2	2	3	89
29	5	2	4	79
30	2	0	2	88
31	3	1	1	89
32	1	2	2	93
33	3	1	1	80
34	3	2	3	93
35	2	2	2	91
36	2	1	2	77
37	2	1	2	102
38	2	2	4	92
39	1	1	2	90
40	0	0	0	86
41	1	1	2	72
42	4	1	1	91

APPENDIX H (Continued)

Student Number	a	b	c[1]	Score
43	2	1	1	89
44	1	1	2	83
45	2	1	2	92
46	3	0	2	91
47	2	2	2	89
48	1	1	4	83
49	3	2	2	82
50	2	1	1	90
51	3	0	1	53
52	2	1	2	83
53	3	0	2	75
54	3	1	2	92
55	3	1	1	59
56	3	0	1	81
57	2	2	2	87
58	2	1	2	90
59	1	2	3	94
60	2	2	2	91
61	2	1	1	83
62	3	2	3	96
63	2	1	2	93
64	3	2	2	80
65	1	1	2	89
66	2	0	2	58
67	1	2	2	96
68	1	1	2	90
69	3	0	1	94
70	3	1	1	84
71	3	1	1	80
72	4	2	3	89
73	3	1	1	101
74	3	0	2	73
75	2	1	2	77
76	1	1	2	78
77	1	1	1	94
78	2	0	2	89
79	2	2	2	82
80	2	1	1	64
81	1	1	1	72
82	2	0	2	84
83	1	1	2	79
84	1	1	4	97
85	2	2	2	90
86	2	1	2	93
87	3	0	1	85
88	2	2	2	74
89	2	2	3	91

APPENDIX H (Continued)

Student Number	a	b	c[1]	Score
90	3	2	2	77
91	2	0	4	76
92	1	1	2	72
93	4	0	1	65

[1]Column a, b, c indicate:

a. Class (1) Freshman, (2) Sophomore, (3) Junior, (4) Senior, (5) Graduate.

b. Sex (1) male, (2) female

c. College (1) Agriculture, (2) Arts and Sciences, (3) Other [Business, Education, Home Economics].

APPENDIX I

COVARIANCE ANALYSIS TABLES

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-TEST SCORES

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
	Analysis of Covariance			
Difference	1	5.32	5.32	0.50
Error	203	2151.14	10.60	

*Difference for testing adjusted treatment means.

$F_{0.05}(1,200) = 3.89$

Null hypotheses. No difference among treatment means after adjusting with covariates

Accepted.

ADJUSTED MEANS AND STANDARD ERRORS

Group	Treatment Mean	Adjusted Mean	SE Adjusted
LD	18.02	18.31	0.31
PDI	19.00	18.64	0.34

TABLE OF COEFFICIENTS, STANDARD ERRORS AND COMPUTED T-VALUES

Error Within

Covariate	Coefficient	Standard Error	t Value
PRE-T	0.43	0.08	5.57
ESS	0.06	0.02	2.80

Treatment & Error (Total)

Covariate	Coefficient	Standard Error	t Value
PRE-T	0.44	0.08	5.90
ESS	0.06	0.02	2.79

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-TEST
SCORES WHEN DIVIDED BY COLLEGE

	Analysis of Covariance			
Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	5	183.10	36.17	3.69
Error	199	1973.37	9.92	

*Difference for testing adjusted treatment means

$F_{0.05}(5,200) = 2.26$

There is a statistically significant difference between the adjusted post-test mean scores when the two groups are separated by college.

Reject H_o: There is no difference in means. A more careful look at the adjusted mean scores was required to answer hypotheses 2 of is study.

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

Group	College	Treatment Mean	Adjusted Mean	SE Adjusted
LD	Agriculture	17.48	17.84	0.42
	Arts & Sciences	18.41	18.63	0.47
	Other*	19.30	19.44	1.00
PDI	Agriculture	16.35	16.73	0.66
	Arts & Sciences	19.67	18.89	0.45
	Other	20.56	20.63	0.79

*Other includes Business, Education, Home Economics

A comparison of adjusted means by t test reveals a significant difference (0.05 level of confidence) in the adjusted mean scores of the PDI Agriculture Group compared with the Arts and Sciences Group. There is significant difference (0.1 level of confidence) in a comparison of PDI Arts and Sciences with PDI Others. For this study, which compares the LD and PDI Groups the H.2 must still be accepted.

TABLE OF COEFFICIENTS, STANDARD ERRORS AND COMPUTED T-VALUES

Error Within			
Covarite	Coefficient	Standard Error	t Value
PRE-T	0.41	0.08	5.44
ESS	0.05	0.02	2.39

Treatment & Error (Total)			
Covarite	Coefficient	Standard Error	t Value
PRE-T	0.44	0.07	5.90
ESS	0.06	0.02	2.79

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-
TEST SCORES WHEN DIVIDED BY CLASS

	Analysis of Covariance			
Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	7	158.64	22.66	2.24
Error	197	1997.83	10.14	

*Difference for testing adjusted treatment means.

$F_{0.05}(7,200) = 2.05$

There is a significant difference in adjusted mean scores when the groups are divided by class.

Reject H_o: There is no difference in adjusted mean scores.

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

Group	Class	Treatment Mean	Adjusted Mean	SE Adjusted
LD	Freshman	18.56	18.19	0.61
	Sophomore	19.03	19.58	0.55
	Junior	16.84	17.39	0.53
	Senior	17.60	17.91	0.83
PDI	Freshman	19.86	19.43	0.68
	Sophomore	19.08	18.88	0.52
	Junior	18.08	17.35	0.63
	Senior	19.28	19.44	1.21

Careful t comparison of adjusted means between LD and PDI Groups reveals no significant differences and H.3 must be accepted.

TABLE OF COEFFICIENTS, STANDARD ERRORS AND COMPUTED T-VALUES

Error Within

Covariate	Coefficient	Standard Error	t Value
PRE-T	0.45	0.08	5.83
ESS	0.06	0.02	2.88

Treatment & Error (Total)

Covariate	Coefficient	Standard Error	t Value
PRE-T	0.44	0.07	5.90
ESS	0.06	0.02	2.78

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-TEST SCORES WHEN DIVIDED BY HIGH SCHOOL SCIENCE AND MATHEMATICS COURSE BACKGROUND

Analysis of Covariance

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	11	155.17	14.11	1.36
Error	193	2001.30	10.37	

*Difference for testing adjusted treatment means.

$F_{0.05}(11,200) = 1.83$

H_o: There is no difference among treatment means after adjustment sith covariates.

Accept H_o.

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

Group	Number of Courses	Treatment Mean	Adjusted Mean	SE Adjusted
LD	0	19.12	20.24	1.17
	1	16.00	16.93	0.70
	2	18.15	18.76	0.56
	3	17.44	17.74	0.76
	4	19.19	18.42	0.72
	5	19.90	18.94	1.04
PDI	0	17.00	17.82	1.32
	1	17.53	17.37	0.83
	2	18.10	18.21	0.70
	3	19.70	19.14	0.63
	4	19.92	19.91	0.93
	5	20.92	19.22	0.99

TABLE OF COEFFICIENTS, STANDARD ERRORS AND COMPUTED T-VALUES

Covariate	Coefficient	Standard Error	t Value
Error Within			
PRE-T	0.40	0.09	4.60
ESS	0.05	0.02	2.56
Treatment & Error (Total)			
PRE-T	0.44	0.07	5.90
ESS	0.06	0.02	2.79

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-TEST SCORES WHEN DIVIDED BY COLLEGE MATHEMATICS AND SCIENCE BACKGROUND

Analysis of Covariance

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	197	2096.92	10.65	0.80
Error	7	59.55	8.51	

*Difference for testing adjusted treatment means.

$F_{0.05}(7,200) = 2.05$

H_o: There is no significant difference among treatment means after adjusting with covariates.

Accept H_o.

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

Group	College Courses	Treatment Mean	Adjusted Mean	SE Adjusted
LD	Chemistry	18.10	18.62	0.60
	Algebra	18.14	18.56	0.87
	Chemistry and Algebra	17.69	17.77	0.52
	Neither Chemistry or Algebra	18.29	18.57	0.59
PDI	Chemistry	19.10	18.91	0.51
	Algebra	16.90	17.30	1.03
	Chemistry and Algebra	18.37	18.03	0.76
	Neither	20.32	19.29	0.72

TABLE OF COEFFICIENTS, STANDARD ERRORS AND COMPUTED T-VALUES

	Error Within		
Covariate	Coefficient	Standard Error	t Value
PRE-T	0.43	0.08	5.46
ESS	0.06	0.02	2.53

	Treatment & Error (Total)		
Covariate	Coefficient	Standard Error	t Value
PRE-T	0.44	0.07	5.90
ESS	0.06	0.02	2.78

COMPARISON OF LD VS PDI ADJUSTED MEAN POST-TEST SCORES WHEN DIVIDED BY MALES AND FEMALES

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio
Difference*	3	75.28	25.09	2.42
Error	201	2081.19	10.35	

*Difference for testing adjusted treatment means.

$F_{0.05}(3,200) = 2.65$

There is no statistically significant difference in the adjusted mean post-test scores of the LD vs PDI Group when divided into males and females.

Accept H.6. No significant difference.

TABLE OF ADJUSTED MEANS AND STANDARD ERRORS

Treatment No.	Treatment Mean	Adjusted Mean	SE Adjusted
1	18.57	18.74	0.36
2	16.67	17.21	0.58
3	18.77	18.39	0.40
4	19.56	19.31	0.62

TABLE OF COEFFICIENTS, STANDARD ERRORS AND COMPUTED T-VALUES

Error Within

Covariate	Coefficient	Standard Error	t Value
PRE-T	0.41	0.08	5.24
ESS	0.06	0.02	3.00

Treatment & Error (Total)

Covariate	Coefficient	Standard Error	t Value
PRE-T	0.44	0.07	5.90
ESS	0.06	0.02	2.79

VITA

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