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COGNITIVE LEVEL AND ATTITUDES TOWARD SCIENCE IN PROSPECTIVE ELEMENTARY SCHOOL TEACHERS: EFFECTS OF INSTRUCTION IN PHYSICAL SCIENCE

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COGNITIVE LEVEL AND ATTITUDES TOWARD SCIENCE IN PROSPECTIVE ELEMENTARY SCHOOL TEACHERS: EFFECTS OF INSTRUCTION IN PHYSICAL SCIENCE

by

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The primary purpose of this study was to examine the relationship of a college course in physical science and the cognitive level of the participants. Effects on attitude, and attitude's related subcategories, were also investigated. Finally, possible relations between cognitive level and science attitudes were analyzed.

The subjects were 62 prospective elementary school teachers at the University of North Carolina at Greensboro. Thirty-one of these students participated in a first-level physical science course at the university. This composed the experimental group. Data were analyzed by t-Ratio, the Product-Moment Correlation Coefficient and the Analysis of Covariance. The significance level was set at the .05 critical value for a two-tailed test.

The experimental treatment was the one-semester course in physical science. Dependent variables were cognitive level and attitude toward science. Attitude was measured by a Semantic Differential scale. Subscales measured evaluation, potency and activity. A written instrument, the Longeot Test, was incorporated to measure cognitive level.

In the cognitive level analysis, no significant changes were detected between experimental and comparison

groups. The results differed from previous research in that relatively higher levels of cognitive performance were detected.

No significant change, either positive or negative, was found with attitude toward science. Expressed attitudes were found to be rather positive. It is undetermined whether this results in more, and better elementary science instruction.

No correlations were found between cognitive level and each of the subcategories of attitude toward science.

This study was in basic agreement with most previous research except for the relatively high attitude and cognitive levels. To investigate this further a poststudy was performed on a very similar population. Attitude was assessed by a questionnaire and cognitive ability by Piagetian tasks. Much lower levels were detected in both areas. Further research must be directed toward the effect of using written instruments versus clinical techniques. Additional research of a long term nature should be directed at defining university instruction that results in improved elementary science education.

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CHAPTER I

INTRODUCTION

Over the last two decades this country has witnessed an increasing concern over the quality of elementary school science. The amount of science taught has been an issue. This widespread concern led to the development of elementary science curriculum studies, including the Elementary Science Study, Science--a Process Approach, and the Science Curriculum Improvement Study materials. While these curricular materials have been incorporated into elementary science instruction in many of the nation's schools, the role of the teacher in utilizing science materials has been inadequately studied. Since the teacher is a critical determinant of instruction, it is important to investigate the extent to which he or she has the ability and desire to work with science in the classroom.

The purpose of this study was to examine the relationship between college physical science instruction for elementary school teachers and (1) their development of cognitive abilities and (2) the change of their attitudes toward science. In addition, the relationship between variables one and two was examined.

Purposes of This Study

The objectives of this study were:

1. To determine the cognitive ability of a selected group of prospective elementary school teachers, as measured by a written instrument, the Longeot examination (Lawson, 1975).

2. To determine the change in cognitive ability as a result of a physical science course.

3. To measure attitude toward science for a group of prospective elementary school teachers using the Semantic Differential method (Osgood, Suci, & Tannenbaum, 1957).

4. To determine the change in attitude toward science as a result of a course in physical science.

5. To examine the relationship between cognitive ability and attitude toward science before the experimental treatment.

6. To examine the relationship between cognitive ability and attitude toward science after the experimental treatment.

Basic Assumptions and Limitations

1. Prospective elementary school teachers who possess a high degree of cognitive ability are more likely to be better elementary science teachers.

2. Prospective school teachers who express a positive attitude toward science are more likely to teach science in their classrooms.

3. The study was limited to elementary education majors at the University of North Carolina at Greensboro (UNC-G). Therefore, the results are limited to that same population. However, the results may be applied to analogous populations.

Definitions and Explanations

1. Formal Operations Ability (abstract ability, logical ability). This is the highest stage in Piaget's theory of cognitive development. It involves the process of developing conclusions through the use of symbols rather than concrete data. Using the words of Lawrence Kohlberg and Carol Gilligan, it is implied that a person with this faculty has the ability to:

> . . . think about thought, and create thought systems or "hypothetico-deductive" theories. This involves the logical construction of all possibilities--that is, the awareness of the observed as only a subset of what may be logically possible. In related fashion, it implies that a belief or proposition is not an immediate truth but a hypothesis whose truth value consists in the truth of the concrete propositions derivable from it. (Kohlberg & Gilligan, 1971, p. 1061)

2. Attitude toward Science is an attempt to assess the subjects' feeling toward the discipline of science. For this study, the method of analysis used was a Semantic Differential scale as described by Osgood et al.(1957).

3. College Physical Science is a two-semester course offered by the Departments of Chemistry and Physics at UNC-G. This study related to the semester course taught by the Physics Department.

Organization of This Study

The original study was performed in the fall of 1977. Two groups of 31 students each were involved in pretesting and posttesting. One group also participated in a physical science course. The quasi-experimental design incorporated a non-equivalent control group format. Following is a tabular description of the experimental design:

Table 1

Experimental Design

Subjects	Pretest	Independent Variable	Posttest
Experimental Group (N=31)	Test 1. Attitude test (Semantic Differential) Test 2. Longeot test of cognitive ability	Course in physical science	Tests 1 and 2
Control Group (N=31)	Tests 1 and 2	No instruction in physical science	Tests 1 and 2

Analysis of the data consisted of a comparison between the pretest and posttest scores of cognitive ability and pretest and posttest scores of attitude toward science. The Analysis of Covariance was used for this purpose. Individual cognitive ability scores were compared with individual attitude scores using a Spearman Rank Correlation Coefficient. This was done to both groups combined, before the experimental treatment. The same correlation statistic was used with each group separately, after the experimental treatment.

The poststudy took place in the spring of 1979. Physics 305 students were again enlisted as subjects. Testing occurred throughout the semester and included two written attitude questionnaires, the same Semantic Differential scale, the Longeot test and three Piagetian tasks. Some results are tabulated but no statistical treatments were applied to these data.

CHAPTER II

REVIEW OF RELATED LITERATURE

Chapter Organization

The first concern of this section was the overall importance of science education. This includes a brief discussion of historical trends in science education and the present emphasis on "inquiry" education. The preparation of elementary science teachers is also given attention. Following that are two sections concerning the major variables of this research: (a) cognitive ability and (b) attitude toward science. Finally, the relationship between these variables and elementary science teachers is discussed.

The Importance of Science Education

The concept of mass education has almost become a trademark of the American way of life. With education being so important to the society, it is not surprising that the historical orientation of our educational processes has responded to the needs of the society. Therefore, to predict the future of science education, we must be sensitive to the flow and direction of our very complex society. Many conflicting signals exist in American society but one trend is universally agreed upon. That is, that our existence is being caught up more and more by science and technology. We are, in fact, becoming a "techno-culture" at an accelerating rate of speed. Revolutions are occurring in theoretical areas as well as applied areas such as space exploration, genetics, exploitation of natural resources, ecology, data processing and medicine. Science is interwoven in the very fabric of our lives. It follows that scientific literacy is a critical element to individuals and to the country as well. However, this means more than the simple fact that scientific wisdom can improve the quality of our lives. Scientific knowledge and political power have become inextricably linked. To maintain control over our own lives, a prerequisite is that we be scientifically literate. The scientist and the politician have become inevitable bedfellows in an indissoluble union of knowledge and power which is epitomized by the "military-industrial complex." Jean-Jacques Salomon (1972) holds that this marriage took place with the construction of the first atomic pile.

> It needed nothing less than the harnessing of nuclear energy and the development of atomic weapons to transform the relationship between science and politics. Hence-forth, the loyalty that the scientist owed, by vocation, to his discipline was to be extended into loyalty owed by him, by function to the State. (Salomon, 1972, p. 124)

Ours is a world faced with the possibilities of nuclear war, mass starvation and global solutions. Scientifically literate citizens could help solve these problems and, further, tap the vast resources of science to actually improve the quality of our lives. But what is a literate citizen? One author (Pella, 1976) lists that person as possessing fifteen different credentials.

1. A literate U. S. citizenry is able to communicate within itself and with other citizens of the world relative to knowledge or ideas of the nature of natural objects and phenomena.

2. A literate citizenry is able to communicate within itself and with other citizens of the world relative to the utilization or control of natural objects and forces.

3. A literate citizenry is able to utilize respected empirical concepts and laws in its constant adjustment to the environment.

4. A literate citizenry is able to explain events in its environment in a rational manner.

5. A literate citizenry is able to predict events in its environment in a rational manner.

6. A literate citizenry is able to read accounts of developments by the scientific community.

7. A literate citizenry is aware of how empirical concepts and laws probably come into being.

8. A literate citizenry is aware of the difference between theoretical concepts and laws and empirical concepts and laws.

9. A literate citizenry can use theoretical laws in unifying (explaining) empirical laws.

10. A literate citizenry is aware of how theoretical concepts and laws come into being.

11. A literate citizenry is aware that the knowledge developed in the scientific community is probable rather than absolute.

12. A literate citizenry knows that theoretical and empirical laws are statements of postulated and/or observed relationships or uniformities, respectively, that are formulated utilizing vocabulary with conceptual meanings that may be descriptive, comparative, or quantitative; hence these laws may be descriptive, comparative, or quantitative.

13. A literate citizenry is able to translate experience with the natural world into knowledge. (The natural world-observation involves perception and mental processes.)

14. A literate citizenry is aware of the regulatory principles accepted in the scientific community that are employed in the generation and application of empirical and theoretical knowledge.

15. A literate citizenry is aware that science is concerned with the empirical universe. (Pella, 1976, p. 99)

This list presents science educators with many formidable goals and, simultaneously, makes us aware that the role of science education differs greatly from what it once was, and, probably, from what it will be. According to Bybee (1977), the structure of science education may be conceived in terms of three different approaches to curriculum and instruction. The first approach is an empirical orientation concerned with scientific knowledge. The second is aimed at the method of science. The third approach is toward the personal development of the student. In the late 1800s, this country was rapidly transforming from an agrarian to an industrial society. Subsequently a knowledge-oriented model of education evolved referred to as "elementary science." This model continued to predominate for some time until the emphasis of John Dewey upon the methods of science began to take hold. This took place in the period leading up to World War II. In the 1960s, a number of curriculum reform projects marked a clear divergence from a singular knowledge orientation. Under the influence of such leaders as Jerome Bruner and Jean Piaget, educators began to emphasize the process of science and the personal development of the student in their pedagogical organization. Much of this effort has come together under the title of "inquiry" education."

"Inquiry" Education

This approach to curriculum and instruction has been described by many terms: discovery, inquiry, and involvement education. It has also affected all levels of instruction.

The emphasis has been on first-person involvement rather than on vicarious science experiences. Research indicates that, although students are often more comfortable in lecture classes, inquiry education can help to develop positive science attitudes (Bybee, 1977).

> . . . It appears from this limited study that some activities, either enjoyable or unenjoyable, leave lasting impressions in the minds of prospective teachers. Also, the enjoyable activities in general involved growing plants, pupil directed experiments, and studies involving animals. (Vannon, 1971, p. 802)

More and more educators are emphasizing the need for active student involvement. In essence, this means the incorporation of inquiry techniques. The need for these techniques on the elementary level has been emphasized (Moorehead, 1965; Smith & Cooper, 1967). However, the most common elementary science method has remained--the reading and discussion of the text; and it has been reported that among certain teachers, the new inquiry-based elementary science curriculum studies (e.g., S.C.I.S., E.S.S., S.A.P.A.) have been used very little. Commenting on the status of elementary school science, one surveyor (Barnard, 1965) listed some of the more common impediments to effective science instruction in the lower grades:

1. Dealing with topics or problems in science which the learner sees no good reason for studying.
2. In an effort to cover the course of study, allowing insufficient time for learners to raise questions and think out their own concepts in relation to the new ones being introduced

3. Overemphasizing verbalization and memorization at the expense of understanding.
4. Usurping the science lesson (by the teacher) at the expense of the overt involvement of pupils. (p. 24)

Some educators have indicated that a vicious cycle has evolved. College science programs have not involved the students in problem-solving inquiry experiences and elementary students have suffered in the same way. The reason that has been projected is that we have tended to teach as we have been taught.

> Too few elementary student teachers appeared to have problem-solving experiences in science teaching in off-campus cooperating schools. This situation may have been created by a lack of emphasis on this approach to science teaching by elementary teachers and supervisors who were responsible for classroom programs in the above schools. (Gant, 1962, p. 543)

Perhaps lecture has become an obsolete method of science education not only in the elementary school but also in the training of elementary teachers.

> In colleges and universities, the courses in elementary science education rarely offer students a teaching model that can be used in or transferred directly to the elementary classroom. The neophyte teacher is supposed to internalize, organize, and translate into meaningful activities for children masses of lecture notes, print, and film. There can be little direct transfer of training between the usual college seminar or lecture course and a classroom of thirty or more active youngsters. (Hone, 1971, p. 319)

Newton (1971) has contended that the main result of teacher education in the United States has simply been an increase in science content retention not related to any increase in critical thinking ability. Educators have become overly-concerned with the appearances of knowledge rather than the real internalization of science concepts:

> It is a depressing reflection on much of what our students have been 'taught' that they come to us deeply imbued with the notion that knowledge resides in names. . . . A slogan of our course has become 'the idea first and the name afterwards.' (Arons, 1972, p. 33)

Professor Arnold Arons has become a proponent of the inquiry approach. He has contended that it is the only available alternative to the failure of verbal instruction (Arons, 1973).

Given the present and future demands that will be placed upon science education versus the current state of affairs in American education, it is important to look at factors that influence the educational process.

The Preparation of Elementary School Teachers in Science

Many problems have plagued teacher training in science. Chamberlain (1955) indicated some of the problems in the science training of present elementary school teachers. These included lack of science background, inadequate facilities, and difficulties in program administration. Williams (1960) conducted a study on the science knowledge of elementary school teachers and developed some surprising data. Teacher scores on a science inventory scale, dealing with life science and the earth, were very similar to those obtained from sixth grade pupils. Another study (Verrill, 1961) also concluded that elementary school teachers have been poorly prepared in science. The immediate reaction to this type of finding has often been the desire to add college science courses for prospective elementary teachers. This has not necessarily been an effective means of improving science competency (Hardin, 1965). Other research (Newton, 1971; Wishart, 1961) seems to support a relationship between science preparation and science teaching competence.

Some research has concerned itself with the amount of science required of elementary education majors. One study (Service, 1964) found the requirements to vary from eight to twelve units. In opposition to this, one survey (Lerner, 1964) indicated that in 22 percent of the teacher training institutions, it was possible to begin teaching with no training in elementary science whatsoever. Whatever the actual status of science in elementary teacher training, increased recommendations for science emphasis in teacher institutions have been heard (Hurd, 1970; Lepp,1960).

Part of the problem may relate to inadequacies in the science method courses that are taught in teacher institutions. Lerner (1964) cited some of these problems as lack of facilities and large class size. Verrill (1961) reports that supervision in science methods courses has generally been very poor. Also, among those polled, it was very rarely required that student teachers teach any science in their classes.

Data have been accumulated in attempts to characterize the elementary school science programs. Biological sciences have been enjoyed and greatly favored by teachers, more so than the physical sciences (Mattheis, 1962; Moser, 1965; Verrill, 1961; Williams, 1960). A survey of 283 pre-service teachers found that 80 percent taught science with 62 percent using inquiry-discovery approaches. Many of the teachers stated that the time allotted for science is not sufficient and 50 percent taught science only in the afternoons. These teachers considered their greatest science teaching assets, in order, to be: (1) their elementary science course; (2) available science materials in their schools; (3) the children in their classrooms; and (4) their philosophies of science teaching. The liabilities listed were: (1) not enough time for science teaching; (2) teacher-student communication; (3) lack of materials; and (4) lack of science content, or background information applicable to the teaching of science in the elementary school (Fulton, Gates, & Krockover, 1973).

What should the proper orientation be with regard to the education of elementary school teachers? The assumption of the present research is that these teachers must (a) have cognitive abilities sufficient to understand the processes of science and (b) have a positive attitude toward science. That is, they must want to teach it. Both concepts--attitude and cognitive ability--are very complex. Specifically, what are they and how do we measure these variables?

Piaget's Theory of Cognition

According to Piaget, learning is a dynamic process between the learner and his environment. The learner interacts with his environment which leads to a subsequent reorganization of his mental "structures" into more functional and fruitful patterns. This process culminates in the mental stage called formal operations. The most novel aspect of this stage is the ability to reason in terms of verbally stated hypotheses as well as by the manipulation of physical objects. This crucial ability allows the person to deduce the logical necessities of stated premises (regardless of the veracity of such premise). The preformal person is tied to the real world while the person at formal operations is able to subordinate the real to the possible.

This ability implies the development of two new mental structures. The first is a combinatorial system whereby the perception of the "set of all subsets" is perceived. Independent of all school training, the formal child can find all possible combinations between elements when the concrete (preformal) child only relates adjacent objects. Though symbolic and physical examples are commonly used with Piaget's theory, combinatorial ability extends throughout a person's experience--even to verbal propositions. This makes possible the attainment of propositional logic, another essential mark of formal thought. The person may now think in an "if--then" manner. The mark of being able to reason correctly through the use of syllogism denotes formal reasoning ability and frees the person from using physical tests to determine the consequences of actions. The presentation of abstract problems before this time produces no "correct answers" in the adult sense. The mental structures operate with internal consistency but cannot deal with the inherent abstractness of the situation. Piaget identifies eight concepts as the earmarks of formal operations ability:

1. Combinatorial Operations. This is a systematic procedure for finding all possible combinations of a group of elements.

2. Proportions. This is the capacity to equate two ratios: $a/b = m/n$.

3. Coordination of Two Systems of Reference. On a balance beam, how may the concept of weight be coordinated with distance to produce the desired effect? This type of logic is the basis of relativistic thinking.

4. Mechanical Equilibrium. An example is the equality of action and reaction.

5. Probability. The understanding that the probability of an event occurring is the ratio of the number of ways that event could happen to the total number of possible events is a formal process.

6. Correlation. This is the realization that two or more events are inevitably linked.

7. Multiple Compensation. A young child, upon seeing milk poured from a squat glass into a slender glass, believes that more milk is now present. He is unable to perceive volume conservation because he cannot simultaneously operate with the several dimensions that define volume.

8. Conservation. This refers to somewhat abstract forms of conservation. We cannot directly observe conservation of energy, and its comprehension is a process of formal thought.

The Assessment of Formal Thought

Piagetian Tasks

In their book, The Growth of Logical Thinking, Piaget and Inhelder (1958) described a series of physical problems used to assess logical thinking ability. There are fifteen experiments.

1. The equality of angles of incidence and reflection
2. The law of floating bodies

3. Flexibility of rods
4. Pendulum
5. Falling bodies on an inclined plane
6. Invisible magnetization
7. Chemical combination of colorless liquids
8. Conservation of motion on a horizontal plane
9. Equilibrium in the hydraulic press
10. Communication vessels
11. Equilibrium in the balance
12. Hauling weight on an inclined plane
13. The projection of shadows
14. Centrifugal force
15. Correlation

The first six experiments require subjects to experimentally manipulate all variables to prove or eliminate hypotheses. This indicates the presence of propositional logic. The remaining experiments test for the presence of formal schemata such as proportion, reciprocity, etc.

Piaget and Inhelder (1958) have used these tasks in conjunction with a "clinical method" involving direct interaction with the child. This has been a source of criticism from some areas. Subsequently, much related research has used more rigid and more standardized procedures. In general, they support the theory of Piaget. Lovell (1961) and Jackson (1965) independently administered a variety of Piagetian tasks to subjects of many ages and intelligence levels. Both authors detected a gradual improvement in ability during all stages. There was, however, a definite break from the concrete to the formal stage at around 11 or 12 years of age. Within each age group, there appeared to be a wide variability in the levels attained. For the most part, subjects were not at the high level of performance demonstrated by the Geneva children with whom Piaget is familiar. Further evidence will be cited indicating that many teenage children and even substantial numbers of adults never attain true formal operations ability.

Some disagreement has existed over whether or not certain tasks actually require and measure higher cognitive abilities. Neimark (1970) indicated that the chemical combinations task does not elicit logic. Lawson and others (Lawson, Blake, & Nordland, 1974) outline a possible source of this common disagreement. The administration of tasks is not always properly practical or even understood. Properly performed, a task should demonstrate agreement with predicted results

> . . . for uniformity and for accuracy. The only real safeguard against mistakes and misinterpretation that arise from limited observations and information is to carefully research the theoretic background of the tasks. (Lawson et al., 1974)

Lawson described the use of an additional task using metal cylinders. The task has reportedly been a useful indication of formal ability if used correctly. The dissonant results surrounding some tasks are more easily understood given the variations in administration.

The theory of Piaget is completely dependent upon the concept of mental structures. These structures make possible the higher cognitive operations. This has led to the experimental necessity of demonstrating these structures. Nevertheless, such research is lacking (Neimark, 1970). Strong intercorrelations between task performance would provide evidence of a coherent structure (Neimark, 1970). Piaget has not provided evidence on this issue, although the same subjects were apparently used for more than one task in The Growth of Logical Thinking (Piaget & Inhelder, 1958). Jackson (1965) reported that, among children of normal intelligence, 60 percent spanned two early cognitive substages. Some spanned up to four stages and 10 percent were consistently placed in one level even through different tasks. Kuhn (1972) and others found much more consistency but indicated that some tasks do appear to be more difficult than others. Neimark (1970) agreed with this. Lovell(Lovell & Shields, 1967) suggested that eight of the tasks were of equivalent difficulty. Correlation and projection of shadows were not judged to be equivalent. Using factorial analysis, Bart (1971a) found that pendulum, motion on a horizontal plane, balance, along with projection of shadows all loaded on a single factor. Lovell and Shields (1967) also reported this loading. Lee (1971) reported that the shadow and balance tasks were related (r = .78).

Usgiris (1964) conducted a study on the conservation ability of 120 grade school children. The sequence in which various conservation abilities were gained was invarient as illustrated through scalogram analysis. The variation that existed at age levels was credited to situational variables. Using two Piagetian tasks--combinations of chemicals and correlations, the diagnostic problem-solving tasks--Neimark (1970) detected a low correlation between combinations of chemicals and the problem solving tasks. The tests were conducted on 61 students and the correlation was significant and consistent. These results were interpreted as consistent with theoretical predictions.

Is the formally operational individual capable of handling the equivalent abstract problems, regardless of the academic discipline the problems are related to? Stone and Ausubel (1969) found that early in formal operations abstract thought in a variety of subject matters was not possible. This phenomenon decreased with age although some persons presumably never reached formal ability in all areas.

While admitting the lack of evidence, Lovell (1971) stated that attitudes toward the academic discipline might influence cognitive function in that area.

> What scattered and fragmentary evidence is available is consonant with the view that training on tasks involving formal thought has little transfer value for the majority of pupils before 13 years of age. Our evidence also supports the view I expressed earlier; namely that knowledge of and attitude toward the subject matter are likely to facilitate formal thought. (Lovell, 1971, p. 91)

Bart (1971a) tested this hypothesis. He administered an interest test and three formal reasoning tests to 90 13-, 16-, and 19-year-olds. The academic areas were biology, history, and literature. All subjects were above average in intelligence. Statistical procedures evidenced that level of interest has little or no association with the level of formal thought demonstrated.

Written Instruments

The need for standardized testing along with more widely available methods of administration has been recognized. Feldman (Feldman & Markwalder, 1971) has observed the following:

> While a great deal of work has been done attempting to replicate Piaget's results, particularly in areas such as conservation and object permanence, little seems to have been accomplished in setting up standardized batteries for diagnostic purposes. The level of a student's or group's cognitive functioning is obviously of importance to the teacher--in planning curricula, instructional strategies, manipulating the educational environment, etc. Piaget's clinical methods are impractical because they require long periods of concentrated observation by trained observers, coupled with the use of non-standardized questioning . . . . (Feldman & Markwalder, 1971, p. 359)

This view has been echoed by others (Ankney & Joyce, 1974; Raven, 1973; Rowell & Hoffman, 1975; Tisher, 1971). The need has not completely overshadowed the inherent difficulties with the pencil-and-paper approach. As Karplus (R. Karplus, E. Karplus, Formisano, & Paulsen, 1975) states:

> Written responses to a group test clearly do not provide the same depth of information about a single individual. There are many reasons why an individual's first response--and that is what he is likely to write down--may not tap all his intellectual resources. Copying from other students and lack of interest also influence the results. Nevertheless, the written task does have an advantage also, in that it permits rapid surveys of large numbers of subjects internationally. At the same time, much of a student's school work is more closely similar to the written task situation than to the clinical interview. Hence, student performance on the written task may help a teacher diagnose learning problems or recognize able students that need additional challenges. (Karplus et al., 1975, p. 1)

In a series of reports (E. Karplus & R. Karplus, 1970; E. Karplus & Wollman, 1974; R. Karplus & E. Karplus, 1972; R. Karplus & Peterson, 1970; R. Karplus et al., 1975) Karplus has presented several tasks that may be administered to groups of individuals. Through correspondence (see Appendix D), Lawson has established the shortcomings of using these tasks as measures of formal ability. He stated that their brevity prevents true measure of the complex and confusing concept of formal operations. Rowell and Hoffman (1975) researched the feasibility of constructing group tests along Piagetian lines. Close to 200 students, of both sexes and a range of ages, were used in the experiment. The researchers adapted the directions for two experiments to paper-and-pencil format, confirmation of chemicals and the pendulum task. The students were allowed to experiment with physical equipment as in the clinical approach used by Piaget. Their responses were written. Results paralleled that of most other research in regard to the age at which formal operations was reached. The degrees to which both tasks provided similar information on particular substages are indicated by a reported product moment correlation of r = .56; S.E. = .05. It was concluded that it is possible to reliably translate into group form, administer, and assess Piagetian indicators of cognitive levels. Many of the students had previous experience with the pendulum experiment. In effect, they had been "taught" the essence of the problem and had all gotten acceptable results during their earlier experiments. However, substantial numbers of these students failed to perform in a manner which could be considered as formal.

Invisible magnetism, equilibrium in the balance, and combination of chemicals were the tasks used by Tisher (1971) to determine the cognitive stage of a number of subjects. Then a paper-and-pencil questionnaire was constructed. It was based on four scientific phenomena: the bouncing ball, equilibrium in the balance, projected shadows, and water levels in connected containers. Twenty-four multiple-choice questions were in the test. Certain connections were made for guessing. There was a 77 percent agreement between the two methods used. A high degree of agreement with other research was indicated. Similar success has been reported by others (Ankney & Joyce, 1974; Polanski, 1974). An instrument developed by Polanski (1974) demonstrated strong correlations with other tests of critical thinking, including Raven's Test of Logical Operations (1971).

The Raven test (RTLO) was designed to assess the logical operations as defined by Piaget and Inhelder in The Growth of Logical Thinking (1958). In addition to this primary goal, other intentions were that the test:

(1) require a minimum of reading;

(2) be capable of administration in a reasonable period of time;

(3) provide a pictorial format for the presentation of problems and possible solutions; and

(4) have sufficient reliability to distinguish persons at various cognitive stages.

Raven reported a reliability coefficient of .79 and a standard error of measurement of 3.4 (Raven, 1973). Evidence of test validity is also reported for the RTLO. A copy of this instrument may be found in Appendix A.

Sheehan (1970) has translated a test developed by M. Longeot which is modeled after the theory of cognitive development of Piaget. Sheehan adapted some of the wording which might have produced some cultural difficulty with

English-speaking students. The structure of the test was not fundamentally altered. He administered the test to 517 New York school children. Their ages ranged from 102 to 186 months. The results demonstrated that, with an increase in age, there was an increase in the percentage of persons in the formal stage. This is consistent with the ontogenetic aspects of Piaget's theory. To test the reliability of the instrument, a preliminary study was completed. It yielded a Kuder-Richardson formula 20 (KR) reliability coefficient of .86. With other populations, similar KR 20 coefficients were reported. It was concluded that the Longeot test was a valid and reliable test of cognitive level.

The test was designed on a pure paper-and-pencil format. Directions are clear, complete, and standardized. Examples are included to prevent confusion among subjects. The test demonstrated a close adhesion to Piaget's theory in that subjects were required to perform those operations which typify the formal stage. These operations include: (1) finding all possible combinations of a set of variables; (2) syllogism; (3) if...then type problem solving; (4) proportional reasoning etc. The format of the test is multiple choice.

An amalgam of Longeot test items was prepared by Lawson (1975a). This variation of the original Sheehan translation (included in Appendix B) has also been referred to as the Longeot test.

Additional Research on Formal Operations

A few researchers have detected a relationship between sex and cognitive ability. Goldschmid (1967) and Weeks (1973) independently reported that male performance on certain conservation tasks was consistently higher than with females. Lawson (1975a) found similar results using formal tasks and a written instrument. In addition, evidence was found which supported the hypothesis that test format differentially affects males and females. Males scored even higher on the written instrument. Male examiners have been used in most studies. Lawson hypothesized that this fact may have accounted for superior male performance. In contrast to these findings, one researcher (Walton, 1975) noticed no performance variation between the sexes. Ninety-five adolescents took part in the study. Two classical Piagetian problems were used along with two social problems requiring logical thought. No differences were found with the generalized cognitive development scores ($F = 1.03$, $p > .05$). Shapiro and O'Brien (O'Brien & Shapiro, 1968) also reported no relation between formal ability and sex, including age x sex interactions.

Virtually all studies have agreed on the relation between chronological age and cognitive stage. It has also been shown that formal operations ability has been positively correlated with mental age (Dudek, Lester, Goldberg, & Dyer, 1969). Since mental age has been determined by specifically designed cognitive tests, those tests appear to have been sampling similar cognitive qualities despite theoretical differences in the tests.

Although some reports (Greaney, 1974; Schwirian, 1969) indicated no relationship between social class and formal operations, more thorough research has pointed out that socio-cultural background has had a significant influence. A large-scale international study (Karplus et al., 1970) investigated this issue using 13- to 15-year-old students in 7 countries. Almost 3,600 subjects participated with approximately the same number of males and females. Students were given various tasks with attention being given to overcome any possible bias resulting from language. Substantial variations were reported between the various cultural groups. Even within one culture, ability related to socioeconomic level. It was hypothesized that the special schooling available to higher social groups was a factor.

Considerable research has been directed at the relationship between age and cognitive stage. By and large, the indication has been that persons reach the various levels at a later date than was indicated by Piaget's experiments. Was this due to above-average intelligence of Geneva school children or of the clinical methods used? That method, it has been hypothesized, may have functioned to direct students into more fruitful paths of inquiry. Whether or not the ages which Piaget claims are boundaries of a stage are accurate has not diminished the theory. Piaget only holds the sequence as inviolate. If children or adults have not reached these stages on schedule, as it has been contended, this makes serious implications concerning our educational approaches. Not surprisingly, children in grades 1-8 do not possess hypothetical deductive reasoning (Shapiro & O'Brien, 1970). It has been contended that Piaget is "correct when he maintains that it is not until 11-12 years of age that a well-developed concept of physical volume is attained" (Lovell & Ogilvie, 1961, p. 126). Whether children of even that age have attained volume conservation is contended by Elkind (1961). Four hundred and sixty-nine junior and senior high school students in Massachusetts acted as subjects. Most of the children came from lower-middle-class homes. Many more students reached abstract conceptions of mass and weight than did attain an abstract conception of volume. Eighty-seven percent attained mass and weight. Forty-seven percent succeeded with conservation of volume. A low but positive correlation between IQ and volume concept was detected. Most progress in volume concept was noted between 12 and 18 years of age. Elkind (1962) performed another study to investigate volume concepts among college students. Surprisingly, a great percentage of students (42 percent) still had not obtained abstract volume concepts. Two hundred forty students took part. Ninety-two percent had acquired abstract conceptions of mass and weight. One fact was at variance with the previous study using high school students. Concept level attained improved throughout college with the women, but not with the men. These results have not altered the important position of "structure" in Piagetian theory. Other research still supports that concept. Phillips (1971) has shown that the method of presentation of tasks was not the key to success. Neither was training relative to a certain task a factor, as indicated in another study (Harris, 1974). These results have pointed up the absolute necessity for a unique mental pattern (structure) in order for growth to continue. Many other studies, however, continue to demonstrate the later-than-expected development of formal operational structures. One study (Keating, 1974) gives some evidence of some earlier-than-expected formal development. A correlation was found with certain psychometric tests. Keasey (1971) experimented with three different age groups: sixth-grade girls, college coeds, and 50-year-old women. Three tasks were given to determine beginning cognitive levels. The subjects then received training on all the tasks. This training followed certain guidelines.

First, it was tailored to the person's cognitive stage. Secondly, it was activity oriented. Thirdly, conflict within the training was encouraged. Lastly, the training process was progressive from simple to complex. The posttesting involved different Piagetian tasks.

Most girls were operating at the concrete level. The majority of coeds were performing at formal operations, and the women, as a group, scored between the young girls and the coeds. Two major conclusions were reported. One, the incidence of the higher stage of logical thinking was rare, even among coeds. With all groups, there was considerable evidence of stage mixture. Secondly, training improved performance on the same task but did not cross over to performance on new tasks.

A study was conducted by Anton Lawson in 1973 to determine the levels of intellectual development attained by high school biology, chemistry, and physics students. Piagetian tasks were used. Of the biology sample, 64.8 percent were either fully or completely at the stage of concrete operations. Approximately 90 percent of the chemistry and physics students were located somewhere above concrete operations, and yet below complete formal operations. Lawson's conclusion:

> These results indicate that a substantial portion of secondary school science subject matter is not appropriate in terms of the intellectual level of the learner. A significant portion of the students are

> still operating largely on a concrete level while science content is largely abstract or formal. (Lawson, 1973, p. 3179)

Colledge (1966) reported similar findings. Though reasoning ability improved with age, most pupils below 16 years of age failed to demonstrate formal thinking or even concrete reasoning.

From research performed with 162 normal junior and senior high school students of both sexes, it was concluded:

> What is clear is that whether formal operational thought is defined in terms of success at some Piagetian task or by Assessing Ss' responses to a more relevant situational problem, relatively few adolescents seem capable, or inclined, to use this mode of thought. This suggests that there is need for considerable revision of the commonly held view that the normal adolescent attains the level of formal operations soon after pubescence. Indeed, it would seem that the normal adolescent is unlikely to reach the level of formal operational thought until his late teens or early twenties if he reaches it at all, and these results suggest that he may well not. (Higgens-Trenk & Gaite, 1971, p. 202)

Another investigation (Bart, 1971b) with high school business students, found only 25.5 percent of the students (N = 51) to be at the stage of formal operations.

The pendulum task required subjects (N = 265) in a Kohlberg and Gilligan study (1971) to exclude irrelevant variables. This is a mark of formal thought. Percentages were obtained to indicate successful completion within each age group:

age 10-15	45%
age 16-20	53%
age 21-30	63%
age 45-50	57%

The researchers concluded that almost 50 percent of American adults never reach adolescence in the cognitive sense. Most who do develop the capacity for abstract thought do so in early adolescence. Some make this advance in their twenties (Kohlberg & Gilligan, 1972). Renner and Lawson (1973) randomly selected 99 eleventh-graders and 97 twelfth-graders. The tasks were conservation of volume and the pendulum (exclusion). The totals indicate the number of successful completions:

Population	Conservation of volume	Exclusion
11th Grade (N=99)		
Females (N=54)	19	14
Males (N=45)	26	23
12th Grade (N=97)		
Females (N=47)	18	16
Males (N=50)	34	20

When the same tasks were given to college freshmen, the following results were obtained:

Number of college freshmen	Conservation of volume	Exclusion
185	133	77

To carry this investigation even further, the tasks were again given, this time to a group of second and third year law students. The research speculated that the "if . . ., then . . ., therefore" construct is the stock in trade of the lawyer (Renner & Lawson, 1973). Therefore, it was expected that this logical ability would be demonstrated through the tasks. The numbers of subjects determined to be at either concrete operations or formal operations are given below:

	Concrete Operational	Formal Operational
Conservation of volume (N=22)	3	19
Exclusion of irrelevant variables (N=44)	13	31

Lovell (1971) indicated that his research agrees with the conclusion that formal thought comes later than results from Geneva would indicate alone.

In a report by McKinnon and Renner (1971), the results of tests performed on 131 college freshmen students were reported. Fifty percent of the students tested were operating completely at the concrete level. Twenty-five percent had not yet fully attained formal operations. Males scored significantly higher than females.

Implications of the Research on Formal Operations

A considerable degree of similarity has obviously been found in many studies relating to formal operations. An extreme variability in cognitive function has been found among subjects. Furthermore, as Karplus has commented:

> It is clear . . . that intellectual development in abstract reasoning . . . reached a plateau in the high school age group and did not progress much further. In addition, the plateau is at a disappointingly low level. (E. Karplus & R. Karplus, 1970, p. 403)

Implications for Curriculum

Research associated with Piaget's theory has been very diverse and much of it is not easily compared. Some conclusions have nevertheless been projected by those involved in the research. Chittendon (1970), speaking in harmony with many others, has stated that instruction which attempts to prove some principles or appeals to logic on scientific experiment is wasted on pre-formal persons. The hypothesis which has grown out of this observation is that teachers, themselves, have not had the kind of experiences with inquiry which could foster cognitive advancement. This has produced a continuing cycle of inappropriate teaching. As McKinnon and Renner (1971) have observed:

> Who is teaching in the elementary and secondary schools? Teachers who have been educated in the existing colleges and universities. Those teachers have been subjected to four years of mainly <u>listening</u> experience. They have been lectured to, told to verify, given answers, and told how to teach. . . . Future teachers, therefore, assume that telling is teaching and when they get their first class, they tell, tell, tell! All the while, very little, if any, intellectual development is going on. If, then, a college student develops logical thought, such development is more by accident than design. (p. 1051)

In short, the call has been heard to let the students experience the environment. Reading about a phenomenon has been a poor substitute for the students over activity

(McCormack & Bybee, 1971). The science teacher has come to be viewed not as a 'teller,' but as a facilitator of investigations. Research on the teaching of science, and physics in particular, has led to the organization of curricular workshops dealing with Piagetian approaches in the science classroom. Some writers have organized helpful teaching guidelines which summarize the in-class methods which enhance stage advancement, and research has been performed to determine the actual effects of such programs and approaches. Thus far, the results have been encouraging.

College Physical Science Courses and Critical Thinking

One study (Daniels, 1962) has demonstrated that students who are proficient in reasoning ability perform somewhat better than others in a traditional physics course. Although reasoning, or problem-solving ability, has been shown to be very complex, the enhancement of this quality is a valid educational goal. Traditional physical science courses have not been shown to improve critical thinking ability while some more experimental approaches and discussion methods have shown some promising results. In the light of these facts, what is the present teaching format in introductory physics courses? An extensive survey by Whitaker and Renner (1974) developed a profile of a typical college physics course. The following data characterized the behavior of instructors in these courses:

> (1) believe that student mastery of the content of physics is the most important objective in the course which they teach;
> (2) believe that student mastery of the content of physics is the most important objective in the individual class periods;
> (3) believe that other objectives, particularly those dealing with the broader, cultural aspects of physics, to be of minimal importance;
> (4) employ lecturing and problem solution by the instructor, but mostly lecturing, as their primary teaching methods;
> (5) ask questions in such a way that a single response is expected or that the instructor himself answers the questions, i.e., primarily convergent or rhetorical questions;
> (6) ask questions which are the least intellectually demanding of the student, i.e., primarily knowledge and comprehension questions which require mainly recall to answer;
> (7) place primary importance upon written materials through reading the textbook or working problems with minimum use of demonstrations or reference to the student laboratory. (p. 827)

These are not behaviors which can enhance abstract thinking.

Elementary school teachers are of crucial importance if these behaviors are to change. They must begin the sequence of cognitive growth by appropriate classroom activities for students. However, most science experiences that prospective teachers have had are not conducive to new teaching methods. Prospective teachers are cognitively at the same level as most other science students in introductory courses. It is not surprising that their critical thinking ability is not enhanced by traditional science programs which incorporate applied instruction.

Attitude Toward Science

Concern for the development of positive attitudes toward science among elementary teachers has grown considerably over the past ten years. This is appropriate since the attitude of a teacher toward a subject area would appear to be an important determinant as to whether or not that teacher will teach that subject. Since our goal is to improve the quality of elementary science education, we must seek methods that help teachers to be pro-science. One difficulty is the very definition of what "attitude" means. Beyond that exists the additional difficulty of quantifying attitude. What is the "meaning" of attitude and how do we measure it? Osgood (Osgood, Suci, & Tannenbaum, 1957) alludes to the difficulty of this pursuit:

> For one thing, the term "meaning" seems to connote, for most psychologists at least, something inherently nonmaterial, more akin to "idea" and "soul" than to observable stimulus and response, and therefore to be treated like the other "ghosts" that J. B. Watson dispelled from psychology. For another thing, it certainly refers to some implicit process or state which must be inferred from observables, and therefore it is the sort of variable that contemporary psychologists would avoid dealing with as long as possible. And there is also, undoubtedly, the matter of complexity--there is an implication in the philosophical tradition that meanings are uniquely and infinitely variable, and phenomena of this kind do not submit readily to measurement. Whatever the reasons, psychologists have generally been quite willing to let the philosopher tussle with the problem. (p. 1)

What is clear is that how a person behaves in a particular situation depends on what meaning that situation has for him (e.g., what attitude he has toward it). As a result, there have been many efforts by social scientists to define and quantify attitude. Insofar as this study is concerned, we will hold to a definition offered by Thorndike and Hagan (1977): "Attitudes relate to tendencies to favor or reject particular groups of individuals, sets of ideas, or social institutions" (p. 395).

Attitude Measurement

Currently, there are a number of instruments available for measuring scientific attitudes. Tests such as the "Scientific Attitude Scale" (Billeh & Zakhariades, 1975), the "Test of Understanding Science" (Cooley & Klopfer, 1961), and the "Facts about Science Test" (Stice, 1958) cover general attitude and science knowledge. An inventory of qualities said to be possessed by scientists was developed by Nay and Crocker (1970). Kozlow and Nay (1976) developed a "Test on Scientific Attitude" which deals with a number of scientific "sub-attitudes." These instruments are currently in use and all possess various strengths and weaknesses. A very common difficulty is quantifying the results that the test, inventory, checklist or survey produces. In attempts to overcome this, a number of researchers (Butzow, 1974; Butzow & Davis, 1975; Butzow & Williams, 1973; Klopfer, 1966; O'Hearn, 1965) have used the Semantic Differential technique specifically to measure science attitude.

Semantic Differential

This approach to attitude assessment was developed by Charles Osgood and his associates (Osgood et al.,1957). It is concerned with the domain of meaning as represented by adjectives. On the basis of factor analysis, Osgood (1957) found that most variations in meaning fall into three dimensions or "clusters." He designated these clusters as evaluative, potency, and activity. Adjective pairs exist which fall into each of these clusters. Some examples are:

Cluster	Adjective Pair
Evaluative	good----------------bad
Evaluative	fair--------------unfair
Potency	strong--------------weak
Potency	dominant------submissive
Activity	busy----------------idle
Activity	active-----------passive

The adjective pairs can help to determine how a person feels about a particular object or concept. This is done by introducing a concept and having the person respond to it by making a mark somewhere between the two adjectives. If the subject marked very close to "good" relative to some concept, we conclude that that person likes that concept. If the subject marked close to "strong," then he or she feels the concept is powerful. The semantic differential is a quick and easy way of determining what a concept means to a person. In addition, the spaces between adjectives can be assigned values and the results can be quantified. One disadvantage is that some adjective pairs might not be appropriate to the concept. The person may be forced into a response that only roughly fits his true feelings.

Preservice and Inservice Elementary Science Teachers' Attitudes Toward Science

Berryessa (1959) conducted a study that investigated the relationship between teacher interest in science and the type of science program that developed. He found that the success of the science program, as measured by achievement, did not depend on the teacher's interest in science. Teachers who were interested in science helped students to perform as well as, but no better than, teachers who did not express a great interest in science. This finding is at odds with most other investigations. Hardin (1965) found attitudes toward preparation in science to be "a useful indication" of science competency. Another study (Piltz, 1954) expressed similar conclusions using a more empirical approach. One researcher (Taylor, 1965) concluded that teacher attitudes are responsible for 18 percent of the variance in scientific achievement. Shrigley (1974) cited several findings which indicate that the teachers' science attitudes influenced pupil attitudes and performance.

Research has been directed at determining the attitudes of prospective elementary school teachers toward science teaching. Cheney (1967) reported the following as some of his conclusions: Preservice teachers interviewed

(1) professed a desire to teach science; (2) accepted the use of apparatus in science by children; (3) expected science to be a favorite subject of many children (p. 3752). Although this seems to depict a favorable situation, much research (Belasco, 1970; Fulton et al., 1973) indicates negative science attitudes. Nordland and DeVito (1974) characterize prospective elementary teachers as follows:

> The combined experiences of the authors working with over 5,000 prospective elementary teachers (PSTs) have demonstrated the inadequacies of the academic preparation prospective elementary teachers receive. Freshmen elementary education majors can be characterized as having a strong negative attitude toward science when they arrive at the university. The range of disaffection runs from boredom and dislike to apprehension and fear. A recent survey by the authors presented an interesting paradox--76% of the students (PSTs) expected to experience difficulty in successfully completing their science requirements, yet an overwhelming percentage (89%) expected science to be the most interesting subject they would teach to children. Unfortunately, exposure to college level science courses does nothing to improve this attitude. In fact, the negative attitude is reinforced.

Perhaps the most thorough survey in this area reported the following among its conclusions (Soy, 1967):

> The prospective elementary teacher comes to college with feelings that he has strengths in the fields of language arts and social studies. During his college preparation he chooses experiences which apparently increase his feelings of strength in these areas. He does not increase his confidence in his abilities in other subject areas in a like proportion. . . .
>
> There needs to be an examination of college curricula in elementary education in order to see what can be done to develop teachers with feelings of competency in a broader range of subject areas, particularly in the fields of science and mathematics.

Along with teachers, school administrators have demonstrated negative science attitudes (Chamberlain, 1955).

Much ambiguity exists on the question of how science knowledge and college preparation in science relate to positive science attitudes. Some studies (Barretto, 1970; Berryessa, 1959; Shrigley, 1974; Soy, 1967) have alluded to a positive correlation between knowledge and positive attitude. How much of this has been an assumption on the part of the author has not been clear. In any case, substantial evidence has supported the opposite position.

In research with elementary teachers (Banks, 1966; Perkes, 1975; Schwirian, 1969) , no positive relationship was found between the amount of science taken in college and positive teacher attitudes toward science. Quite a number of comparative studies (Berkland, 1974; Lawfer, 1974; Mattheis, 1963; Oshima, 1967; Siemro, 1974) failed to detect any significant attitude change toward elementary science among teachers, some of whom were involved in experimental science courses. Perhaps these diverse findings are due to an intimation (Bruce, 1969) that attitudes toward science are largely formed before college.

Schwirian (1969) investigated science attitudes as they relate to several variables. From this she produced a tentative characterization of the "most scientifically positive teacher" and the "least scientifically positive teacher."

> Our "most positive teacher" would most likely be a person under 40 years of age who has graduated from a state school where he has taken ten or more hours of

> science courses. By contrast, our "least positive teacher" would tend to be an over 40 year old graduate of a liberal arts college who took less than ten semester hours of science while attending college. In neither case may we characterize him by sex, religion, or the grade level he teaches. (p. 211)

Although Dutton (Dutton & Stephens, 1963) has indicated a highly positive attitude toward science among prospective elementary school teachers, this is a highly subjective evaluation. Indeed the choice of attitude scales has been a highly subjective process in itself. Using the Dutton scale or similar instruments, some studies (Gaides, 1963; Hoover, 1970) have indicated that certain experimental science programs can enhance these attitudes among elementary education majors. This is an important finding. How have attitudes toward science and the formal operational ability of the elementary teachers affected the degree to which science is taught on the elementary level? This is a poorly researched question. One or two studies have initiated related research. Nordland (Nordland & DeVito, 1974) used 17 college freshmen and 19 college sophomores as subjects in a related study at Purdue University. All were enrolled in a course entitled "Biology for Elementary School Teachers." Although the research was primarily concerned with test-retest reliabilities, data were generated which indicated the Piagetian level of the elementary educational majors. Five Piagetian tasks were used: two conservation of volume tasks, exclusion, separation of variables, and equilibrium. Three percent were established to be at the early concrete level. Thirty-six percent were late concrete. Fifty percent were early formal, and 11 percent were late formal.

The Undergraduate Preservice Teacher Education Program--An Integrated Science Approach for Preservice Elementary Teachers was a program undertaken at Purdue University. As reported by Renner and Lawson (1975), the program philosophy was that many students, being concrete thinkers, need concrete problems and meaningful inquiries to facilitate the acquisition of formal reasoning ability. Hence, the major information source was laboratory experience of an inquiry nature. Six Piagetian tasks were administered to an experimental group of 20 students and a control group of 17 students. Subjects were mostly female with a mean age of 19.0 years. The control group students were enrolled in a traditional physics course for elementary teachers. Posttests were given to both groups after one year of instruction. The scores received by subjects were the averages of individual stage scores (ordinal measures) from each of the tests. One significant datum was generated. Applying the Mann-Whitney υ Test, the mean gain of the experimental group (1.10) was significantly higher than that of the control group (.35) at the .01 level (V = 99.5, p = .01).

This study answers several questions but bares some unresolved questions. The use of tasks, even by experienced personnel, is still a subjective evaluation. What would be the results with a more objective instrument? Also, would a larger sample verify the Purdue results? The use of tasks presents still another difficulty. Statistically, is the averaging of ordinal statistics (stage levels) a biased procedure? These questions relate to partial replication of the preceding study. Other questions also arise. How effective would group testing procedures be? What relationship does science attitude have to formal operational ability and how are these variables affected by a course in physical science?

CHAPTER III

RESEARCH DESIGN

The overall concern of this study was the quality of elementary school science education. The presumption was made that, to have excellent instruction in science, the society must have teachers who want to teach science and who have the mental ability to understand science. These two prerequisites to science instruction have been referred to as (a) attitude toward science and (b) formal operations (cognitive) ability. Using two written instruments, the primary study investigated these two variables among a group of elementary education majors at the University of North Carolina at Greensboro. What is the effect of our undergraduate curriculum on these variables? This question was investigated by testing students both before and after a one-semester course in physical science. Statistical analyses were used to determine if cognitive ability and science attitude had any correlational relationship. A poststudy was performed to determine if the written research instruments were measuring the qualities of science attitude and cognitive ability. This was done using subjective attitude questionnaires, manual Piagetian tasks, Semantic Differential and the Longeot test.

Major Research Objectives

1. To investigate the cognitive abilities of sixty-two preservice elementary school teachers at the University of North Carolina at Greensboro.

2. To investigate the attitudes toward science of sixty-two preservice elementary school teachers at UNC-G.

3. To examine the effect of a course in physical science on cognitive ability.

4. To examine the effect of a course in physical science on science attitude.

5. To calculate the statistical correlation between cognitive ability and science attitude, using the same subjects, before they participated in a course in physical science.

6. To calculate the statistical correlation between cognitive ability and science attitude after the subjects participated in a course in physical science.

Experimental Design

To investigate these objectives, a quasi-experimental research design was employed. This was necessary, and desirable, because of the nature of the experimental treatment--the course in physical science. Participation in that course could not be anything but voluntary thereby ruling out randomized procedures. As an alternative to this, a nonequivalent control group design was used in conjunction with statistical procedures (ANCOVA) to adjust for the non-equivalence. Written instruments were employed to pretest and posttest the experimental and comparison groups. All four testing sessions incorporated the same instruments.

Operational Definition of Variables

Attitude Toward Science

Referring back to the definition of "attitudes" supplied by Thorndike and Hagan (1977): "attitudes relate to tendencies to favor or reject particular groups of individuals, sets of ideas, or social institutions" (p. 395). "Attitude toward science," therefore, was the tendency to favor or reject the concept of science. The concern of the study was that, if prospective teachers expressed negative science attitudes, they would reject science (teaching) in their classrooms. In all research, the meaning of a variable is largely determined by the instruments used to assess that variable. Since a Semantic Differential scale was used to assess attitudes in this study, science attitude was said to consist of three dimensions: evaluative, potency, and activity. These are the dimensions that Osgood (Osgood et al., 1957)referred to in The Measurement of Meaning.

1. Evaluative dimension--The primary factor of attitude. The feeling of whether a thing is good or bad.

2. Potency dimension--This is concerned with power and the ideas associated with it such as size, weight and toughness.

3. Activity dimension--This is concerned with quickness, excitement, agitation and the like.

Formal Operations Ability

The highest cognitive level, as defined by Jean Piaget, is the stage of Formal Operations. A major characteristic of people in this stage is that they can successfully interact with the world about them through the use of abstract concepts. They are not tied to strictly "concrete" interactions.

Method of Data Collection

The treatment group was tested (pre and post) during two regularly scheduled laboratory sections. A brief explanation was supplied to enlist the subjects' help but the purpose of the testing was not elaborated upon.

This was done to avoid any conscious distortion of the data. Enlistment of the control group was far more difficult. This was performed on a strictly voluntary basis. Of course, the identical group of 31 subjects had to be retested leading to considerable problems in logistics. A cooperative group of control subjects was crucial to the successful implementation of the design since testing occurred during the free time of the subjects.

Research Instruments

The choice of research instruments was guided by several factors. First, it was predetermined that the analysis of data would depend on the use of parametric statistics. Since the analyses would ultimately involve the comparison of means, it was desired to reduce error variance as much as possible. This was done by the following means:

a. a simple and straightforward administration requiring no clinical experience.

b. standard and unambiguous instructions.

c. the use of standard, non-subjective, test items.

d. a written format to reduce the time necessary for administration, thereby helping to control distortion of the results due to disgruntled subjects.

It was most important to maximize experimental variability. To succeed in this, it was crucial to have a large number of test items.

Semantic Differential Scale

As discussed in the previous chapter, many instruments for scientific attitude assessment are available. But, as Kozlow (Kozlow & Nay, 1976) states:

> (Most suffer) . . . from one or more of the following shortcomings: the definitions of attitudes are too general; there is a tendency to lump together several dimensions of science under the caption of attitudes (e.g., interests, attitudes and values are grouped with processes involved in scientific inquiry); the

> scales do not discriminate between the affective and cognitive components involved in attitude measurement; and the content of the scales often does not adequately represent classroom situations and experiences. (p. 148)

For this reason, an instrument was desired which tested the pure concept of "science" without any complications. Many attitude questionnaires require a "yes" or "no" response making them insensitive to small variations in attitude. Also, how one question should be weighted relative to another is usually not considered. This produces data of an ordinal level only and prohibits the use of statistical reasoning. An instrument was desired that had segments of approximately equal weighting. An advantage to the use of Semantic Differential was that, by factor analysis, Osgood (Osgood et al., 1957) discovered adjective pairs (questions) that (a) were located in the same dimension and (b) had the same attitude value. For example, useful-useless and important-unimportant are two adjective pairs that fall into the evaluative dimension. The factor loading for each pair is identical, meaning that, when a subject places a mark beside "useful," he is answering essentially the same question, <u>with the same emphasis</u>, as when he marks beside "important."

As Osgood (Osgood et al., 1957) states, there is no one Semantic Differential scale. The particular scale used is a product of the researcher and is fitted to his needs.

> Although we often refer to *the* semantic differential as if it were some kind of "test," having some definite set of items and a specific score, this is not the case. To the contrary, it is a very general way of getting at a certain type of information, a highly *generalizable technique of measurement* which must be adapted to the requirement of each research problem to which it is applied. There are no standard concepts and no standard scales; rather, the concepts and scales used in a particular study depend upon the purposes of the research. Standardization, and hence comparability, lies in the allocation of concepts to a common semantic space defined by a common set of general factors, despite variability in the particular concepts and scales employed. It is true, of course, that in some areas of measurement, e.g., psychotherapy or attitude, a particular form of the differential, with standardized concepts and scales, may be developed, but there is no general "semantic differential test" as such. (Osgood et al., 1957, p. 76)

As mentioned, the Semantic Differential technique has been widely employed as an instrument to measure attitude. Several researchers have used it directly to measure science attitude and Butzow (Butzow & Davis, 1975) developed and validated a Semantic Differential scale for teacher attitude toward teaching elementary science.

Construction of the Semantic Differential Scale

The particular instrument used in this study (see Appendix B) was developed according to the guidelines described by Osgood (Osgood et al., 1957) in *The Measurement of Meaning.* The three principle attitude clusters were incorporated into the test. Evaluation was considered to be the most important to the study; therefore most bi-polar adjective pairs are evaluative. The following table lists the attitude pairs used and their respective dimensions.

Table 2

Semantic Differential Attitude Pairs

Dimension	Bipolar Adjective Pair
Evaluation	meaningful-meaningless
	cruel-kind
	positive-negative
	bad-good
	timely-untimely
	wise-foolish
	true-false
	painful-pleasurable
	important-unimportant
	beautiful-ugly
	regressive-progressive
Potency	hard-soft
	humorous-serious
Activity	slow-fast
	active-passive

The left-right arrangement of all pairs was randomly determined to prevent repetitive behavior by the subjects. The potency and activity pairs were placed at periodic intervals to help eliminate "halo effect." A descriptive example of the scale used is supplied below.

SCIENCE

meaningful				X				meaningless
cruel					X			kind
positive			X					negative
hard		X						soft
bad						X		good
timely					X			untimely
slow					X			fast
wise			X					foolish
true		X						false
humorous					X			serious
painful		X						pleasurable
important		X						unimportant
active					X			passive
beautiful	X							ugly
regressive						X		progressive

In this example, the positive side of each adjective-pair is underlined. Sample checks are supplied. With the important-unimportant pair (counting from the low side), the subject would increase his evaluation total score by six points for placing the check where he did. The total scores gained by the sample checks are as follows:

evaluation	55
potency	11
activity	8

Since a score of four indicated a neutral score for any given adjective pair, the nature of one subject's score or the mean of a group of scores can be obtained by dividing each dimension by the number of pairs used from that dimension. With the example used, the evaluation score of 55 was obtained by totaling the scores from all eleven evaluation pairs, giving a mean evaluation score of five. Two potency and two activity pairs were used. The potency average is 5.5 (slightly positive) and the activity average is 4 (neutral).

<u>Longeot Test</u>

The original Longeot test was developed and validated in France. The English translation appeared in a dissertation by D. J. Sheehan (1970). Sheehan obtained a reliability coefficient for the same test (see Appendix D). Few written instruments have been developed specifically around Piaget's Theory of Cognition as has the Longeot test. As a result, the test possesses construct validity as Sheehan attests (see Appendix D). Each section of the test is concerned with a cognitive area that Piaget considers important to concrete or formal reasoning. Section I involves questions on syllogistic reasoning. Section II requires probabilistic reasoning. Part III requires the use of if--then reasoning, a keystone of formal thought. Part IV requires the subject to structure all possible combinations among given variables.

Included in this document are a number of research reports in which the Longeot test has been used. As Lawson points out (see Appendix D), the test is advantageous over (Karplus) tasks because of its greater length. This helps to decrease error variability, particularly since no clinical training is necessary for administration. A large number of items can be administered in a short period of time which maximizes experimental variability. Since cognitive development is a continuum, a research instrument was desired that would be sensitive to more than just a discrete stage. The Longeot test, it was thought, would allow sensitivity such as "high-formal" or "low-formal."

Scoring

Twelve correct answers was regarded as the maximum score indicating concrete logic. Thirteen or fourteen correct answers were scored as transitional between concrete and formal operations. Fifteen correct answers was the minimal score indicating formal reasoning ability.

Longeot Validation

The use of written instruments to assess formal operations ability is still in its infancy. It was perceived as desirable to secure evidence that the Longeot test was, in fact, measuring higher cognitive abilities, as defined by Piaget. To do this a prestudy was performed in the summer of 1976. The study enlisted thirty college age people as subjects. Each subject was given the Longeot test and in addition, was given two Piagetian tasks. A Spearman Rank Correlation Coefficient was calculated between individual Longeot scores versus combined scores on the two tasks. The two tasks were the "Pendulum" and "Equilibrium" as described by Piaget and Inhelder (1958) in The Growth of Logical Thinking.

Oscillation of a Pendulum

The pendulum problem utilizes a simple apparatus consisting of a string attached to a bar (Figure 1). The string length can be varied and various masses can be attached to the lower end of the string. Note the illustration. The subject was presented with this apparatus and was asked to find the factor(s) that determine the frequency of oscillation. The subject may have thought that any one of several variables was important. These variables included mass, length of the string, the height of the drop or the push given the mass. Since only the length of the string was relevant, the problem was to eliminate the other, irrelevant, variables. The subjects' responses to this problem were categorized as being indicative of a particular cognitive stage. A score of one, two, three or four was possible. A score of one was indicative of preoperational thought. The subject was unable to differentiate between

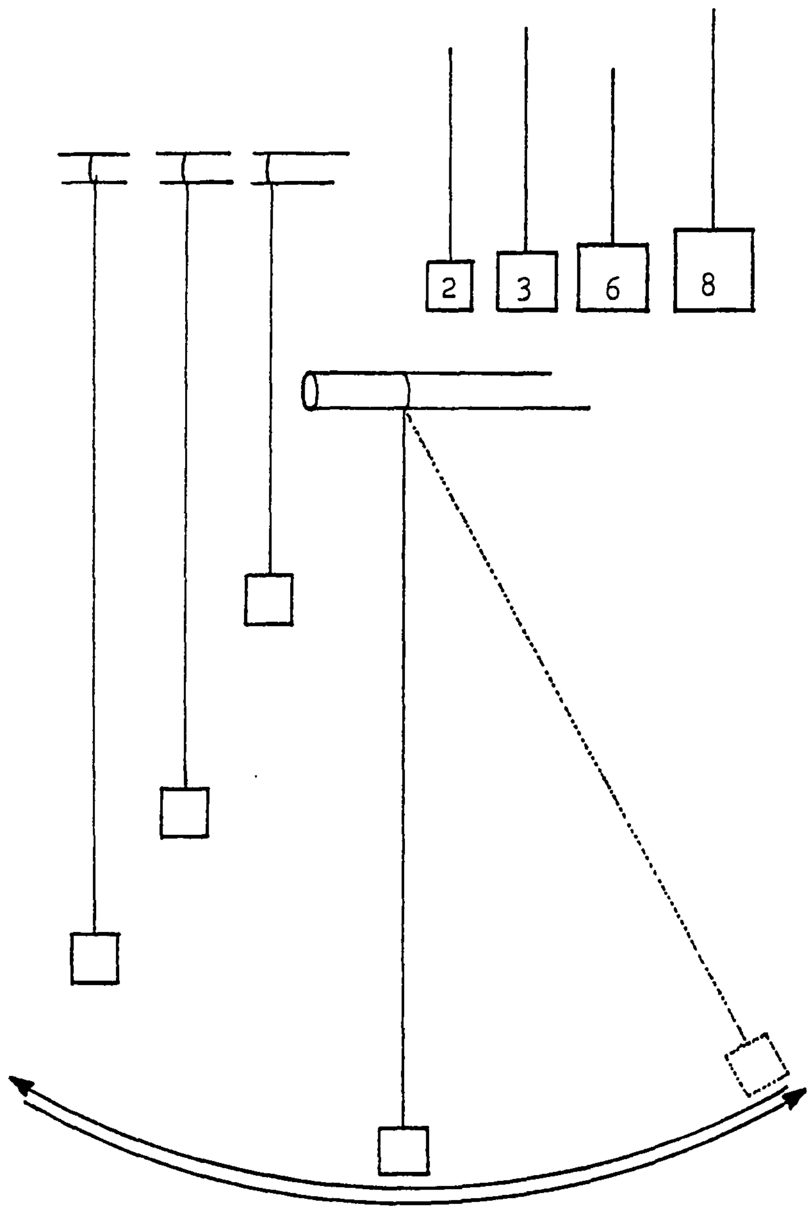

Figure 1. The pendulum

his own actions and the effect on the pendulum. That is, the motion imparted must be the causal factor. Subjects received a score of two if they were able to order the variables but unable to isolate individual variables thereby solving the problem. A score of three was assigned if the subject separated out one variable at a time but was unable to do so in a systematic way. This indicated crude formal operations ability. True Formal Operations ability earned a score of four. These subjects would perform a true experiment, varying only one factor at a time and solving the task.

Equilibrium in the Balance

This was a test of proportional reasoning. A balance beam was used (Figure 2). Various weights could be attached along points on either side of the axis. The subjects were presented with this apparatus. Two unequal weights would be attached at unequal distances on both sides. The subject was asked to make the beam balance. If the subject believed that the only factor relating to balancing the beam was his own action (i.e., pushing it), that subject was behaving at the sensorimotor level and received a score of one. Concrete Operations behavior was evidenced when the subject experimented with weights and distance but in an unsystematic manner. This called for a score of two. A score of three was given if the subject detected the proportionality involved in a

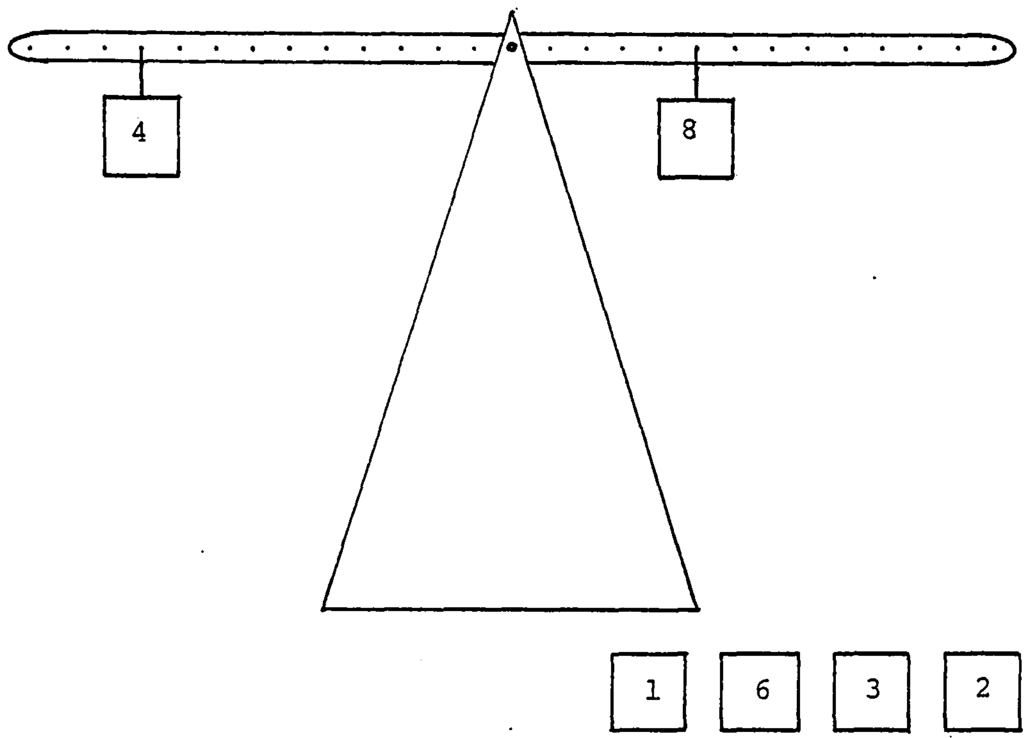

Figure 2. Equilibrium

qualitative way. "Heavier ones have to be closer in." True Formal Operations behavior received a score of four. Here the subject was able to balance the beam and discover the inverse proportionality relationship.

Results of Validation Study

The data from this experiment include individual scores, by subject, for the Balance and for the Pendulum. This is followed by a combined score and then a mean score. The mean score corresponds to Piagetian stages as follows: 1--Sensorimotor; 2--Concrete; 3--Early Formal; 4--Late Formal. Many of the mean scores indicate transition. Longeot scores are recorded by section and then by total. Section 1 included questions 1 through 9. Section 2 (L2) was questions 10 through 20. Questions 21 and 22 were Section 3, and 23 through 28 were Section 4. These results are presented in Table 3.

From these results, a correlation coefficient of r = .22 was calculated. This was not significant at a 5 percent alpha level (r = .361). However, the results demonstrated that high task scores tended to parallel high Longeot scores. Piaget lists a number of characteristics of Formal Operations ability. These characteristics were not paralleled in each mode of testing with the one exception being proportionality. This was only approximate since the balance beam requires the understanding of an <u>inverse</u> proportion. The comparison between task results

Table 3

Prestudy Results

Subject	Balance	Equilibrium	Total	Mean	L1	L2	L3	L4	Longeot Total
1	2	2	4	2.0	9	6	2	6	23
2	3	2	4	2.5	9	5	1	6	21
3	4	4	8	4.0	7	4	2	6	19
4	2	2	4	2.0	9	9	2	6	26
5	4	4	8	4.0	8	7	2	4	22
6	3	3	6	3.0	9	8	1	1	19
7	3	3	6	3.0	9	5	0	0	14
8	1	1	2	1.0	8	7	5	1	21
9	4	3	7	3.5	9	9	2	6	26
10	2	4	6	3.0	8	4	2	4	18
11	4	3	7	3.5	9	9	2	5	25
12	3	4	7	3.5	9	10	2	2	23
13	3	3	6	3.0	9	9	2	6	26
14	3	3	6	3.0	9	4	2	6	21
15	2	4	6	3.0	9	6	2	5	22
16	2	2	4	2.0	9	8	2	5	25
17	3	3	6	3.0	9	9	2	6	26
18	3	2	5	2.5	9	10	2	6	27
19	4	4	8	4.0	8	8	2	6	24
20	3	2	5	2.5	9	6	2	4	21
21	2	2	4	2.0	9	4	1	3	17
22	3	3	6	3.0	9	8	2	6	25
23	3	2	5	2.0	9	8	2	6	25
24	2	2	4	2.0	8	7	2	2	21
25	2	3	5	2.5	9	9	2	5	25
26	2	3	5	2.5	9	6	2	5	22
27	3	2	5	2.5	9	7	2	1	19
28	2	4	6	3.0	9	9	2	6	26
29	4	4	8	4.0	9	9	2	6	26
30	3	3	6	3.0	9	7	2	5	23

L1--Longeot test, first section
L2--Longeot test, second section
L3--Longeot test, third section
L4--Longeot test, fourth section

and between Longeot subsection results demonstrated that formal reasoning in one area does not insure formal reasoning in another. Since the Longeot test was concerned with many other areas (syllogistic reasoning etc.) it was not discarded as a research instrument on the basis of a statistically nonsignificant comparison with two Piagetian tasks. The rough correlation was judged to be reasonable assurance that scores would be similar in either mode. This judgment was made in light of scant evidence relating to the effect of testing mode on Formal Operations performance. Using the scoring procedures already outlined, it was noticed that 15 of the subjects were judged to be at the same stage in each test. Eight were transitional (between concrete and formal) on one test and formal on another. Seven of the subjects tested out in different stages depending on whether the Longeot test or the tasks were used as the guide.

Specific Research Objectives

The research objectives were defined in light of the research instruments used.

1. To examine the attitude toward science of a group of 62 elementary education majors:

a. relative to the evaluative dimension as measured by a Semantic Differential scale;

b. relative to the potency dimension as measured by a Semantic Differential scale;

c. relative to the activity dimension as measured by a Semantic Differential scale.

2. To examine the cognitive ability of a group of elementary education majors as measured by the Longeot test.

3. To examine the effect of a course in physical science upon cognitive ability.

4. To examine the effect of a course in physical science upon attitude toward science and its subdimensions:

a. evaluative;

b. potency;

c. activity.

5. To examine the relationship between cognitive ability and attitude toward science:

a. cognitive ability versus evaluative factors;

b. cognitive ability versus potency factors;

c. cognitive ability versus activity factors.

6. To examine the effect of a course in physical science upon the relationship between:

a. cognitive ability and the evaluative dimension of attitude;

b. cognitive ability and the potency dimension of attitude;

c. cognitive ability and the activity dimension of attitude.

Sample

Sixty-two persons cooperated as subjects in the study. All of them were elementary education majors at the University of North Carolina at Greensboro. The 31 members of the experimental group were enlisted from the physics 305 laboratory section. Therefore, the students in this group were under different lecture instructors. There was a total of 3 lecture instructors. The experimental group was completely female. The comparison (control) group consisted of 30 females and one male. None of these students was enrolled in Physics 305, nor had they ever been. They were enlisted principally from a Children's Literature course for elementary education majors. Their participation was voluntary.

Experimental Treatment

The experimental treatment was a one-semester course in Physical Science structured specifically for UNC-G elementary education majors. The experimental group studied Physics 305, the comparison group did not. The course text was *Conceptual Physics* (Hewitt, 1974). Mathematical demands were not burdensome. Each student had three hour-long lecture sections each week. Each lecture instructor had unique approaches and emphases in his section. One instructor used a highly interactive technique using Piaget's Theory of Cognition. Students were administered tasks to ascertain their cognitive level. Hands-on investigations were frequently used. Another instructor, being in a new environment, held sections that were rather unstructured. The possible carry-over to attitude toward science, as used in this study, was difficult to determine. That same instructor ran the laboratory section for all Physics 305 students. The labs involved work with elementary school children at a local public school. The physics students chose science experiences which they thought would be beneficial to the young children. These included such things as a "batteries and bulbs" investigation and an experiment with levers. The college students would work with the elementary children in small groups. In follow-up sessions, the students compared notes on which experiences they found to be successful with the children. Following is a handout that was given to the Physics 305 students at the beginning of the course. The syllabus indicates that typical physical science topics were the principal lecture topic.

Physics 305
Fall 1976

Text: Conceptual Physics by Paul Hewitt, Second Edition
Instructor: Dr. G. T. Hageseth
Room 102, Science

DATE			TEXT	LAB
August	30	M	Chapter 1	Lab Orientation
September	1	W	Chapter 2	
	3	F	Chapter 3	
	6	M	Chapter 4	Pendulum
	8	W	Chapter 4	
	10	F	Chapter 5	
	13	M	Chapter 5	Acceleration Due to Gravity and Energy Conservation
	15	W	Chapter 5	
	17	F	Chapter 6	
	20	M	Review	Balanced Meter Sticks
	22	W	TEST 1	
	24	F	Chapter 7	
	27	M	Chapters 8 & 9	Conservation of Momentum
	29	W	Chapter 10	
October	1	F	Chapter 11	
	4	M	Chapter 13	Archimedes' Principle
	6	W	Chapter 14	
	8	F	Chapter 14	
	11	M	Chapter 15	Calorimetry
	13	W	Chapter 16	
	15	F	Chapter 17	
	18	M	Fall Break	NO LAB
	20	W	Chapter 18	
	22	F	Review	
	25	M	TEST 2	Speed of Sound
	27	W	Chapter 19	
	29	F	Chapter 20	
November	1	M	Chapter 21	Ohm's Law and Electrical Wiring
	3	W	Chapter 22	
	5	F	Chapter 23	
	8	M	Chapter 24	Electrical Appliances and EKG
	10	W	Chapter 25	
	12	F	Chapter 26	

DATE			TEXT	LAB
November	15	M	Review	Electromagnetism
	17	W	TEST 3	
	19	F	Chapter 17	
	22	M	Chapter 29	NO LAB
	24	W	Chapter 28	
	26	F	Thanksgiv-ing Break	
	29	M	Chapter 30	Image Formation
December	1	W	Chapter 31	
	3	F	Chapter 32	
	6	M	Chapter 33	Radioactive Isotopes
	8	W	Chapter 33	
	10	F	Review	

1. Students are required to attend all laboratory periods.
2. The grading scale is 90-100, A; 80-89, B; 70-79, C; 60-69, D; 59 and below, F.
3. Each one-hour test counts 20%; the lab grade counts 20%; and the final exam counts 20%
4. In order to pass the course, the student must have a grade average of 60 or above on the three tests and final exam. The lab grade will not count if the tests and final exam average is below 60.
5. Students are required to take all three hour tests and the final exam. The final exam will include all of the material that was covered during the semester.

Analysis of Data

From the individual Semantic Differential scores, pretest and posttest means were calculated for the control group and the experimental group. Evaluative means were higher because more adjective pairs were used. Raw scores (number of correct answers) were obtained from the Longeot tests. These were averaged to supply pretest and posttest means for both the control and the experimental groups. Standard deviations were calculated for all means. In all cases, statistical comparisons involved comparing means. Correlation coefficients were calculated between cognitive ability and the three attitudinal dimensions. This was performed using pretest and posttest data. However, with the posttest information, the experimental and control groups were separated before calculation of the correlation coefficients. The purpose was to assure sensitivity to any effects of the independent variable on the relationship between cognitive ability and science attitude. To determine how similar or dissimilar the experimental group was to the control group, t-test scores were calculated for all dependent variables between both groups. The nonequivalent control group design of the experiment had, as its major weakness, the possibility that the control group and the experimental group were dissimilar before the application of the independent variable. To adjust for this, the Analysis of Covariance was used to correct for any variance in pretest means (experimental vs. control). For the Analysis of Covariance, the significance level was set at the .05 critical value to determine any significant difference between posttest means.

CHAPTER IV

RESULTS

The raw data from the experiment are presented, by subject, in the Appendix, Section E. This chapter presents descriptive statistics calculated from the data and frequency polygons of the test scores. Correlation coefficients are calculated for (a) affective measures versus cognitive ability for both groups collapsed (pretest), and (b) affective measures versus cognitive ability for the experimental and control groups separately (posttest). Pretest t-scores are given between the experimental and control groups. Analysis of covariance scores and statistics are presented.

Attitude Toward Science

The following tables (Tables 4 and 5) present the mean pretest and posttest scores for the three attitudinal dimensions. Figures 3 through 8 are frequency polygons of individual subject performance. A neutral score was eight.

Only moderate differences were found between the control and treatment groups. Pre- and postmeasurements also show similarity. The distribution of the data demonstrates a fairly strong similarity of attitude within the groups. The one exception to this is the

Table 4

Potency and Activity Scores

		Attitude-Potency		Attitude-Activity	
		Pretest	Posttest	Pretest	Posttest
EXPERIMENTAL GROUP	Number	31	31	31	31
	Mean	10.42	10.13	9.94	10.23
	Standard Deviation	2.43	2.01	2.59	2.59
CONTROL GROUP	Number	31	31	31	31
	Mean	10.74	10.32	9.94	10.07
	Standard Deviation	2.08	2.17	2.32	2.10
TOTAL	Number	62	62	62	62
	Mean	10.58	10.23	9.94	10.15
	Standard Deviation	2.25	2.08	2.44	2.40

Table 5

Evaluation Scores

		Attitude-Evaluation	
		Pretest	Posttest
EXPERIMENTAL GROUP	Number	31	31
	Mean	57.81	58.16
	Standard Deviation	8.39	8.76
CONTROL GROUP	Number	31	31
	Mean	56.74	55.61
	Standard Deviation	5.66	6.84
TOTAL	Number	62	62
	Mean	57.27	56.89
	Standard Deviation	7.11	7.90

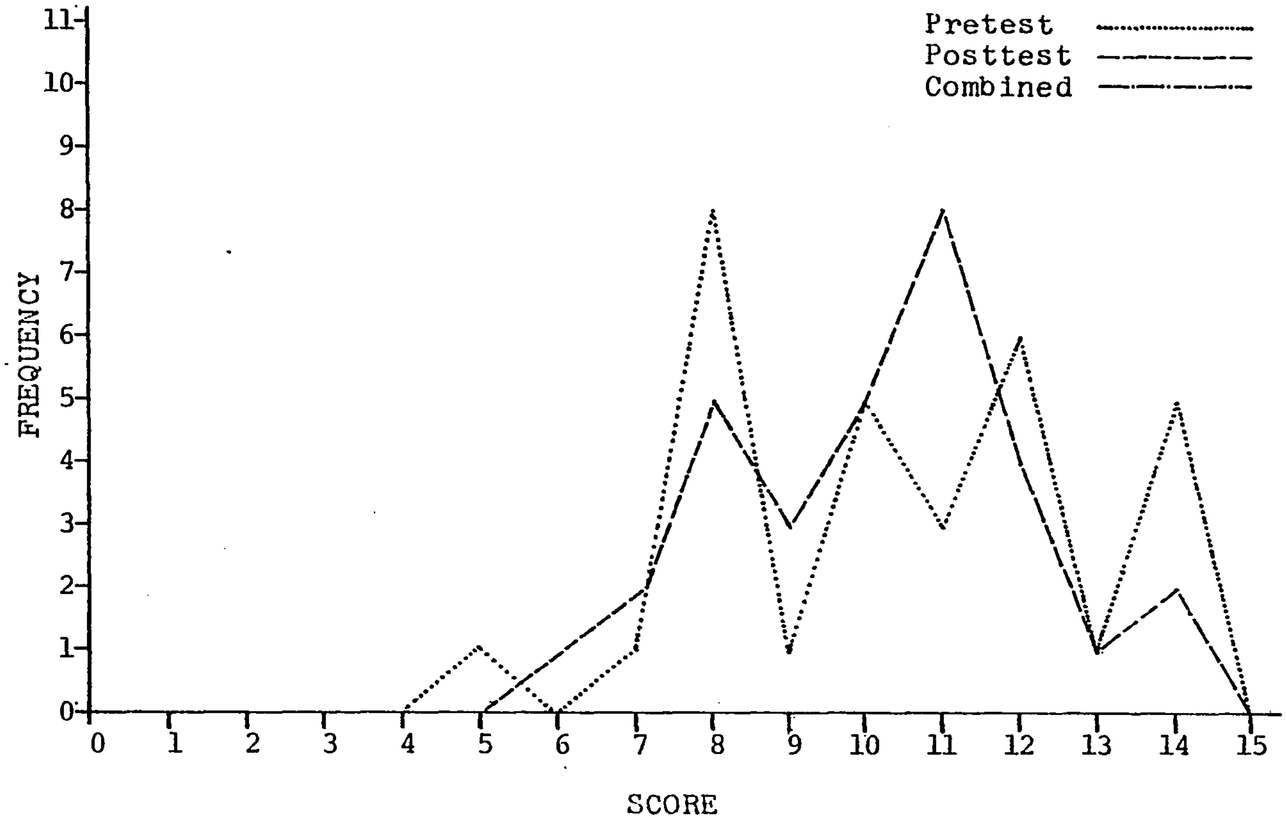

Figure 3. Attitude potency-experimental group (N=31)

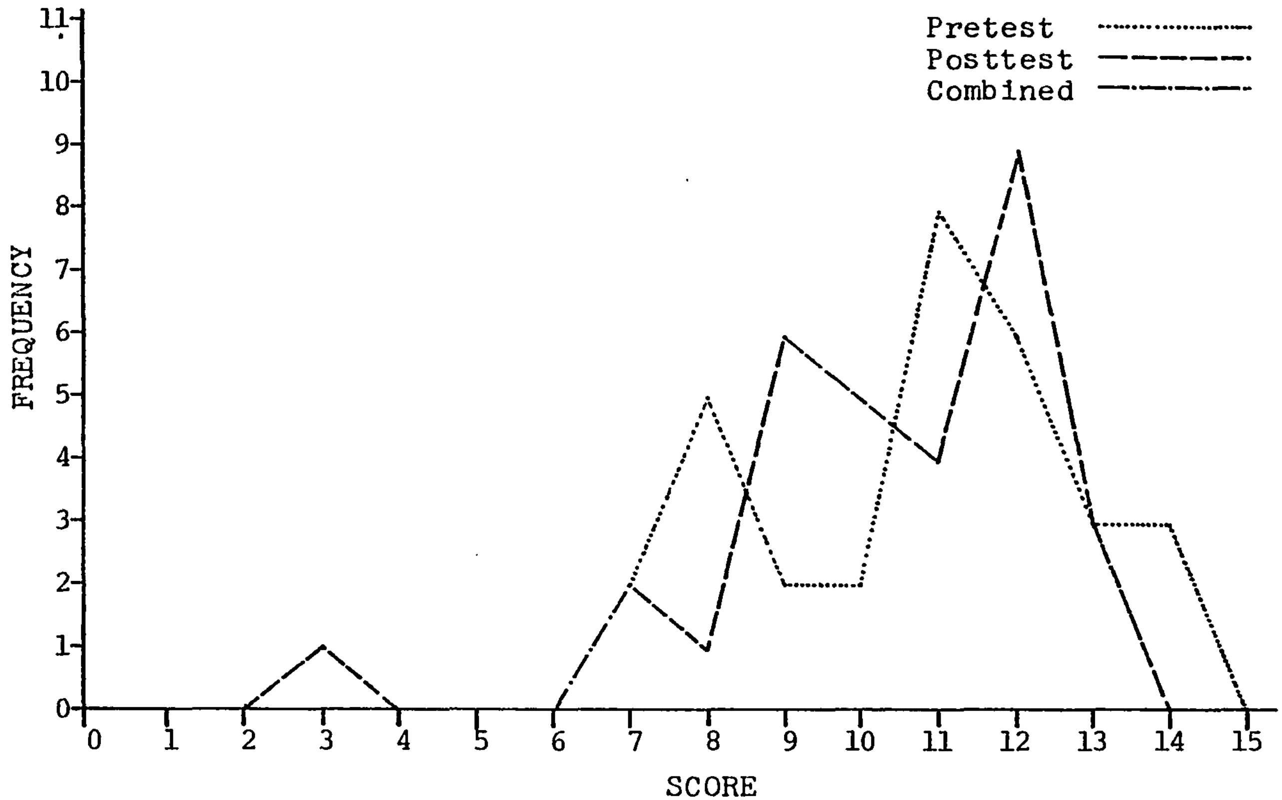

Figure 4. Attitude potency-control group (N=31)

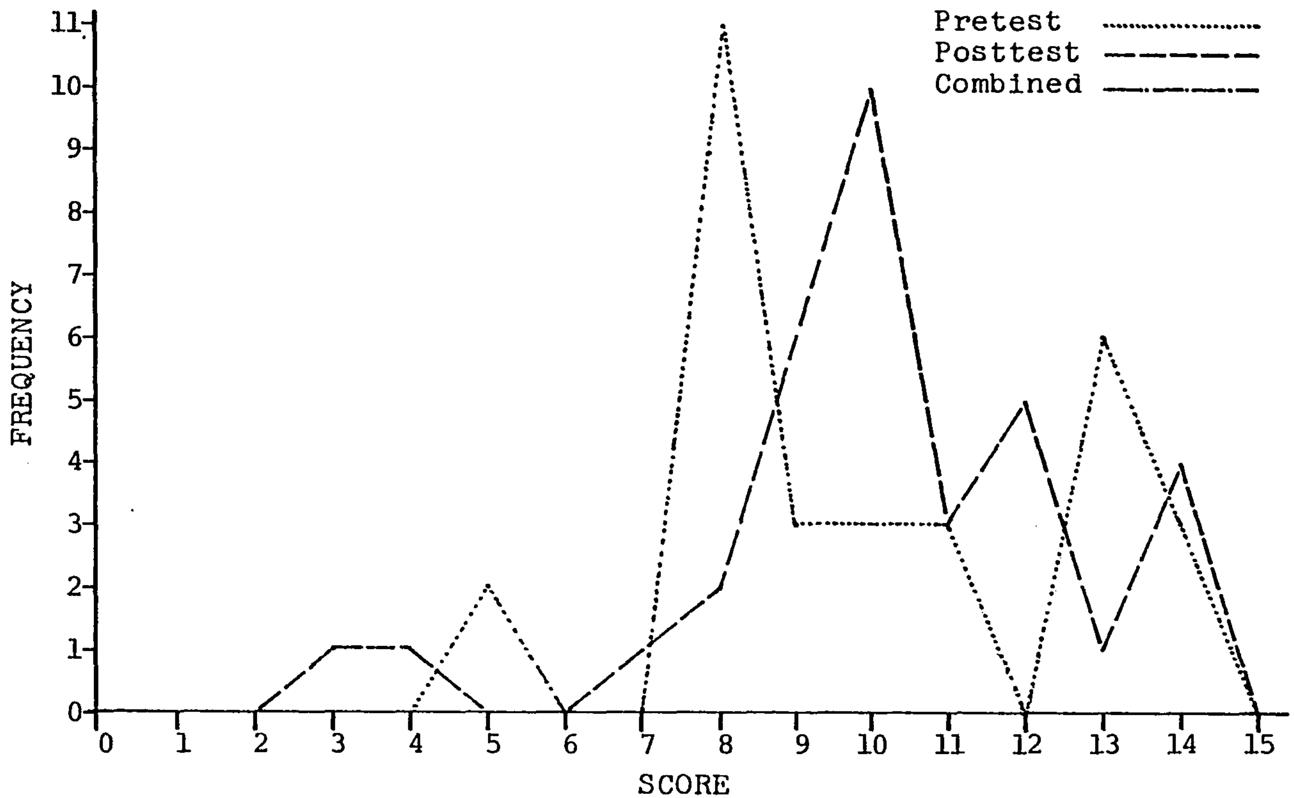

Figure 5. Attitude activity-experimental group (N=31)

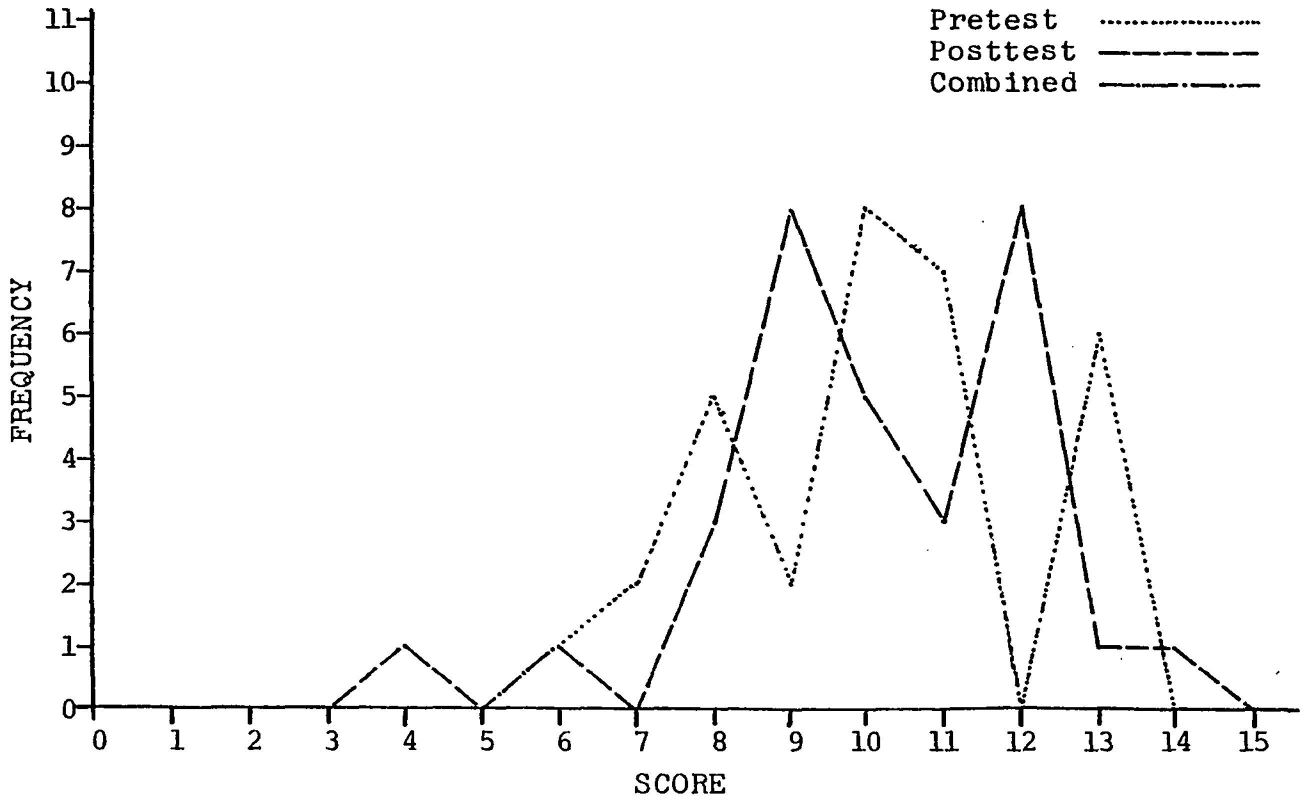

Figure 6. Attitude activity-control group (N = 31)

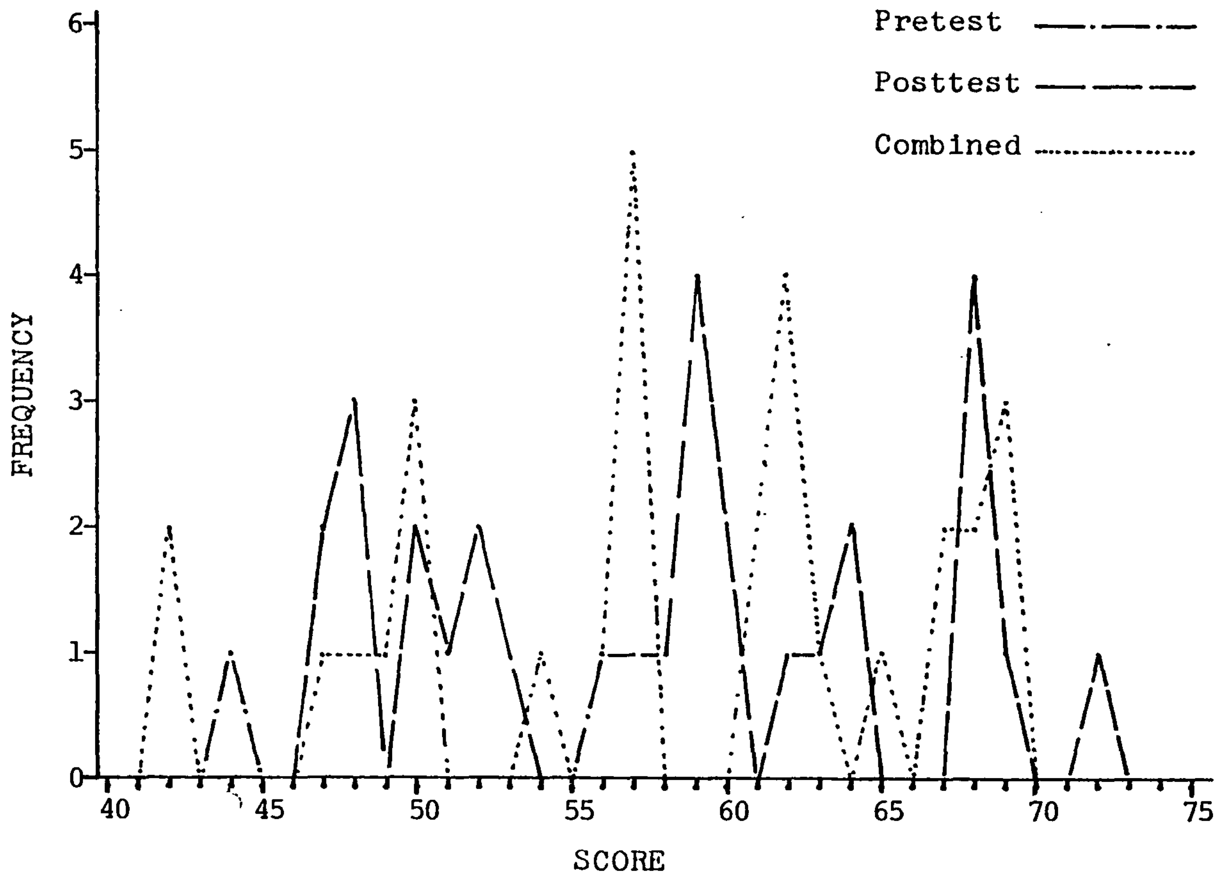

Figure 7. Attitude evaluation-experimental group (N=31)

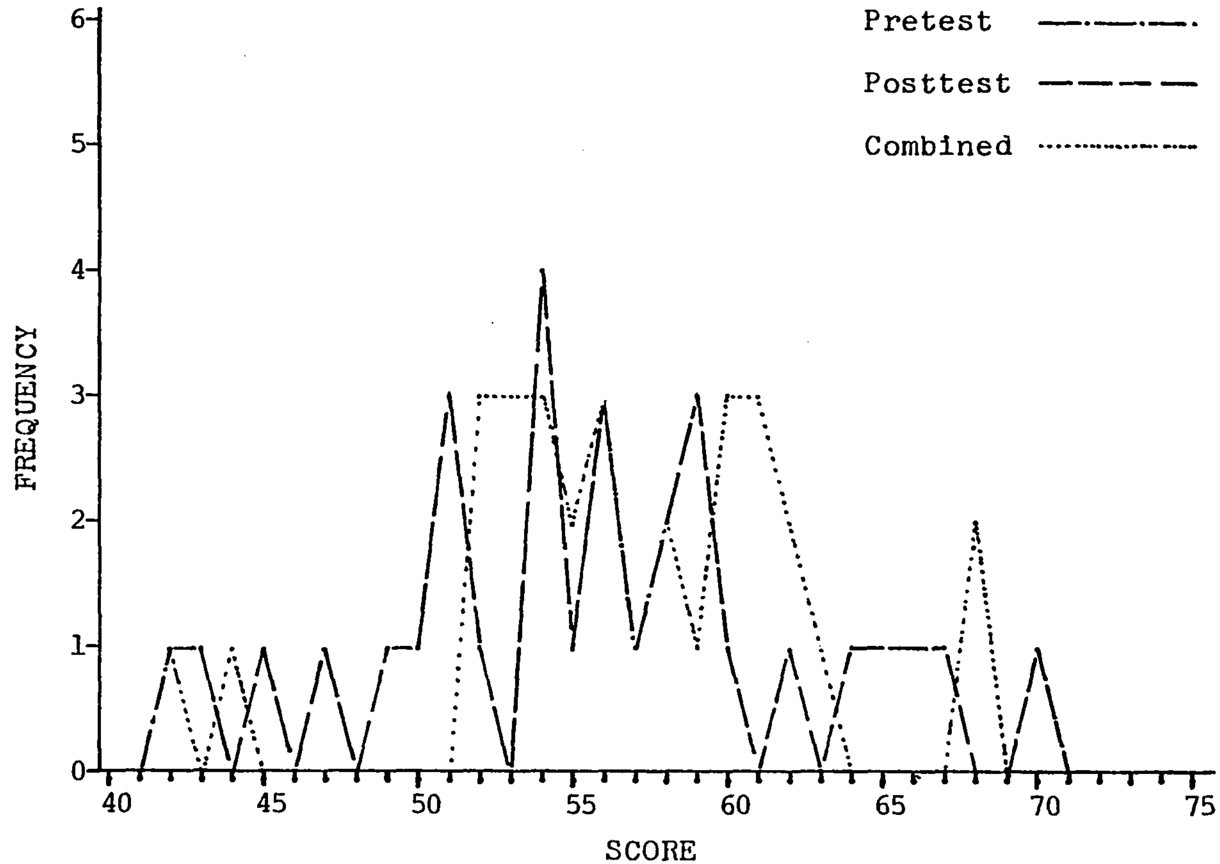

Figure 8. Attitude evaluation-control group (N=31)

dispersed distribution of experimental group evaluation scores. This is reflected in the standard deviation scores of 8.39 and 8.76. Control group standard deviations were only 5.66 and 6.84. Relative to attitude-evaluation, the experimental group was a more heterogeneous group.

Pretest scores were almost invariably above neutral. Since this disagreed with previous research and with other data from the same population, the question arose: What is the written instrument actually measuring? The post-study was performed to help answer this question.

Effects of Physical Science Instruction upon Attitudes to Science

Table 5 lists pretest and posttest data relating to attitude. The following data include t-test scores to describe how similar or dissimilar the pretest groups were as to attitude evaluation, potency and activity.

The magnitude of the F value indicates a substantial difference in variability between the two groups (S.D. = 8.38 versus S. D. = 5.66), requiring the calculation of a t value by separate variance estimates. The calculated t value is not significant and would be attributed to chance 56 percent of the time.

The F value of 1.26 indicated that no significant variance resulted from the treatment. The covariate

Table 6

Evaluation Pretest: Experimental Versus Control

T-Test

Experimental Mean	57.81
Standard Deviation	8.38
Standard Error	1.50
Control Mean	56.74
Standard Deviation	5.66
Standard Error	1.02
F Value	2.19
2 Tailed Probability	0.04
Separate Variance Estimate	
T Value	0.59
Degrees of Freedom	52.67
2 Tailed Probability	0.56

Table 7

Evaluation Posttest by Treatment Group

(Covariate-Evaluation Pretest)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Covariate (evpre)	714.43	1	714.43	13.93	0.001
Treatment Group	64.63	1	64.63	1.26	0.265
Explained	779.06	2	389.53	7.60	0.001
Residual	3025.20	59	51.27		
Total	3804.20	61	62.36		

F value (13.93) was significant only in that the covariate explained most of the small variance present. These results are similar to those that follow for other co-variates. Almost all of the variability was explained by the initial variance between treatment and comparison groups.

Table 8

Potency Pretest: Experimental Versus Control

T-Test

Experimental Mean	10.42
Standard Deviation	2.43
Standard Error	0.44
Control Mean	10.74
Standard Deviation	2.08
Standard Error	0.37
F Value	1.37
2 Tailed Probability	0.40
Pooled Variance Estimate	
T Value	-0.56
Degrees of Freedom	60.00
2 Tailed Probability	0.58

The 1.37 F value is an indication of similar variance, allowing the calculation of a pooled variance estimate. The t value is attributable to chance (58%).

Table 9

Potency Posttest by Treatment Group

(Covariate-Potency Pretest)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Covariate (popre)	48.84	1	48.84	13.47	0.001
Treatment Group	0.066	1	0.066	0.018	0.999
Explained	48.91	2	24.45	6.74	0.002
Residual	213.93	59	3.63		
Total	262.84	61	4.31		

The between group variance versus the within group variance (F value) is significant if all factors are taken together. However, the mean square value for the covariate is responsible for almost all of the variance. After adjustment for potency pretest scores, the treatment group variance is not significant and would almost always (99.9 percent of the time) occur simply by chance alone.

Table 10

Activity Pretest: Experimental Versus Control
T-Test

Experimental Mean	9.94
Standard Deviation	2.59
Standard Error	0.47
Control Mean	9.94
Standard Deviation	2.32
Standard Error	0.42
F Value	1.25
2 Tailed Probability	0.55
Pooled Variance Estimate	
T Value	0.00
Degrees of Freedom	60.00
2 Tailed Probability	1.00

The two distributions are almost identical, as indicated by mean and standard deviation values. Subsequently, any possibility of significant difference is excluded by the 0.00 t value.

Table 11

Activity Posttest by Treatment Group
(Covariate-Activity Pretest)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Covariate (acpre)	83.79	1	83.79	19.81	0.001
Treatment Group	0.40	1	0.40	0.09	0.999
Explained	84.19	2	42.10	9.95	0.001
Residual	249.50	59	4.30		
Total	333.69	61	5.47		

The activity pretest covariate causes a significant (0.001) degree of variation. After correction for that variance, the independent variable does not cause a significant effect (F = 0.09).

The t-test data indicated that the pretest experimental and the pretest comparison groups were not significantly dissimilar. Nevertheless, the Analysis of Covariance was used to correct for any differences. No significant results were detected as a result of the experimental treatment. With regard to evaluation, a very slight increase occurred in the experimental group and there was a slight drop in the comparison group mean. Potency decreased slightly in both groups and activity increased slightly.

<u>Cognitive Ability of Prospective Elementary School Teachers</u>

Table 12 displays the mean scores for the Longeot test, both experimental and comparison groups.

Table 12

Longeot Scores

		Pretest	Posttest
Experimental Group	Number	31	32
	Mean	21.29	21.36
	Standard Deviation	3.59	4.14
Control Group	Number	31	31
	Mean	19.74	19.16
	Standard Deviation	4.22	4.42
Total	Number	62	62
	Mean	20.52	20.26
	Standard Deviation	3.96	4.39

Figures 9 and 10 are frequency polygons of individual pretest and posttest data for the experimental and control groups.

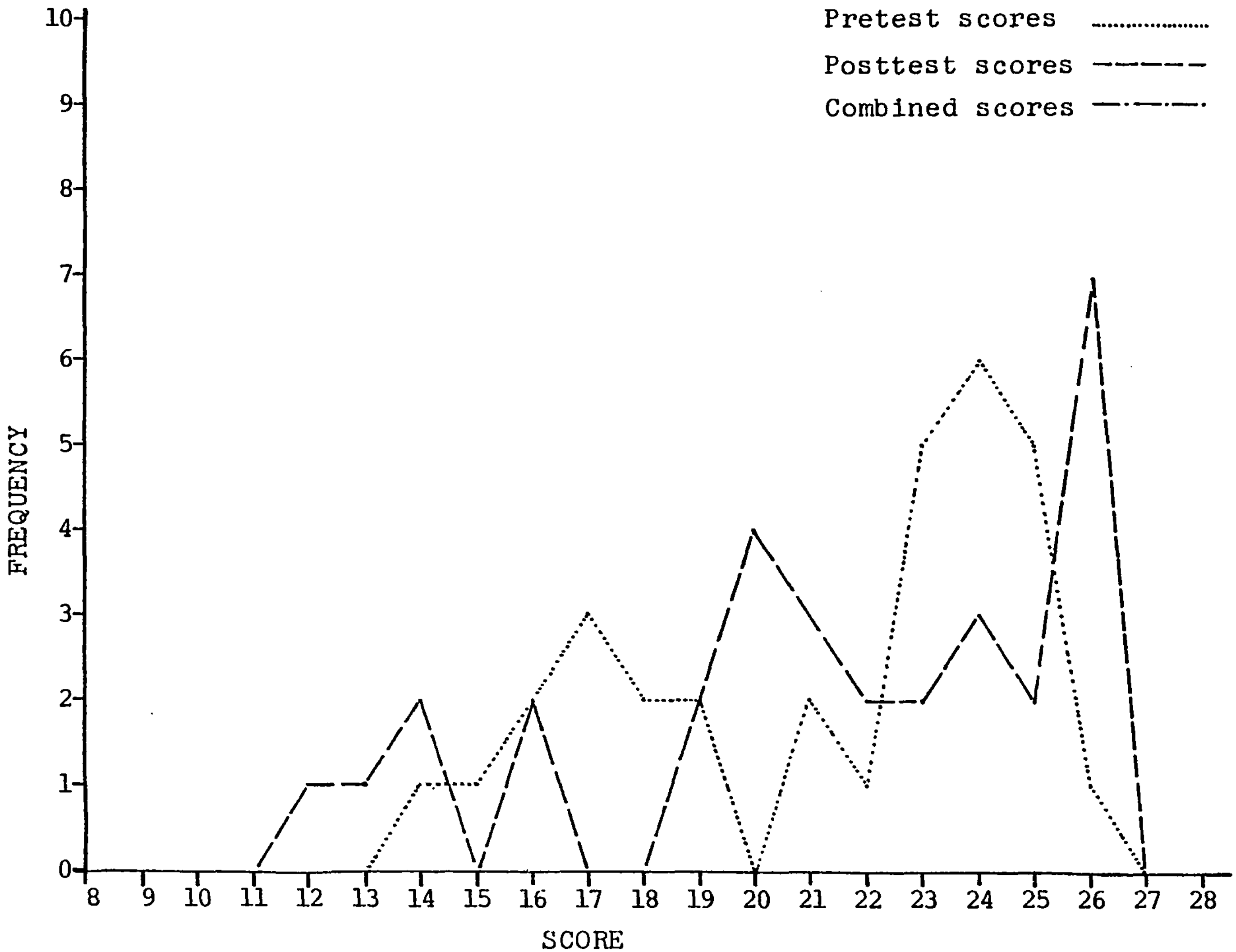

Figure 9. Longeot scores--experimental group (N=31)

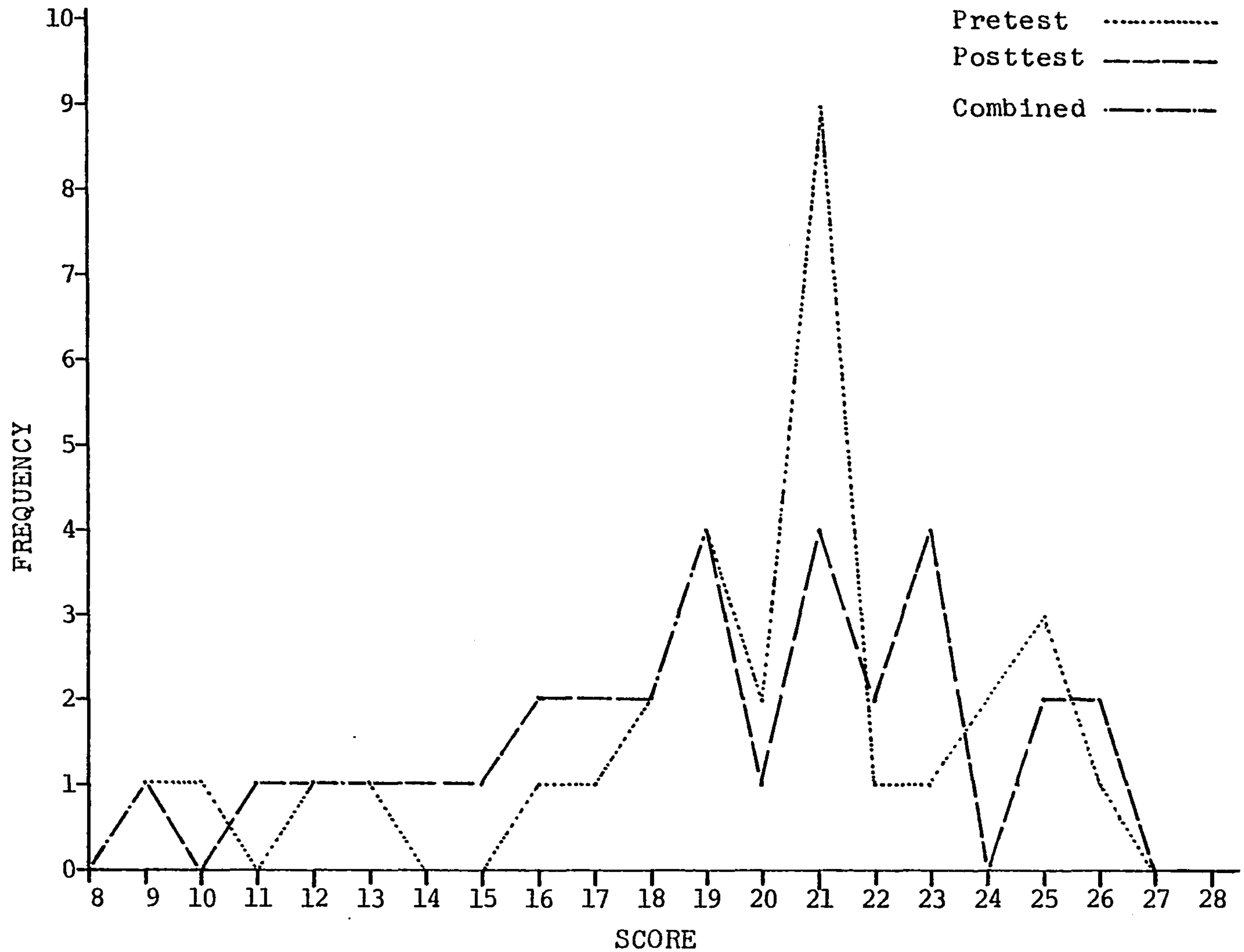

Figure 10. Longeot scores--control group (N=31)

Effect of a Course in Physical Science on Cognitive Ability

Table 13 displays a t-Test comparison of Longeot scores between the two groups.

Table 13

Longeot Pretest: Experimental Versus Control

T-Test

Experimental Mean	21.29
Standard Deviation	3.59
Standard Error	0.65
Control Mean	19.74
Standard Deviation	4.22
Standard Error	0.76
F Value	1.38
2 Tailed Probability	0.38
Pooled Variance Estimate	
T Value	1.56
Degrees of Freedom	60.00
2 Tailed Probability	0.12

Table 14 displays the data from the Analysis of Covariance, used to determine the effect of the independent variable.

No significant variation exists between pretest groups but, relative to the treatment effect, the Longeot pretest scores form a significant covariant.

Table 14

Longeot Posttest by Treatment Group

(Covariate-Longeot Pretest)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Covariate (pre)	684.79	1	684.79	84.80	0.001
Treatment Group	12.60	1	12.60	1.56	0.214
Explained	697.39	2	348.70	43.18	0.001
Residual	476.47	59	8.076		
Total	1173.865	61	19.244		

Both groups showed substantially similar pretest and posttest performance. The experimental group performance was slightly superior, both before and after testing. Both groups experienced a slight and nonsignificant decline in performance. The groups were not significantly different during pretesting and the experience of the experimental treatment did not alter that fact.

Relationship Between Cognitive Ability and Science Attitude

The possibility of correlations between Longeot scores and attitude scores was investigated through the calculation of the Pearson (product-moment) correlation coefficient. This was performed between Longeot scores and all three attitude variables. Furthermore, although the experimental and control groups were collapsed for the pretest data, both groups were separated for the calculation of the posttest data. This arrangement made the experiment sensitive to the question of whether or not the independent variable influenced the correlation.

Table 15

Longeot Pretest Versus Evaluation Pretest

(Both Groups)

Correlation (r)	0.17
r Squared	0.03
Significance	0.09
Standard Error of the Estimate	3.94

The correlation (0.17) is low and explains only three percent of the observed variability among Longeot scores. If evaluation pretest scores were used as predicters of Longeot scores, 68 percent of the predicted scores would fall within a range 7.88 points (two Standard Error of the Estimate widths) wide. This range would be centered around the mean and is very similar to the observed standard deviation. Thus, the predicting value is very low.

Table 16

Longeot Pretest Versus Potency Pretest (Both Groups)

Correlation	0.18
r Squared	0.03
Significance	0.07
Standard Error of the Estimate	3.93

The low correlation (0.18) is capable of predicting three percent of the observed variability.

Table 17

Longeot Pretest Versus Activity Pretest (Both Groups)

Correlation	0.11
r Squared	0.01
Significance	0.18
Standard Error of the Estimate	3.97

Activity pretest scores can predict only one percent of the reported variability in Longeot scores. Hence, no correlation exists. The Spearman Rank scores that follow split the experimental and control groups to detect any effects of the independent variable upon the correlation of the dependent variables.

Table 18

Longeot Posttest Versus Evaluation Posttest

(Experimental)

Correlation	0.05
r Squared	0.003
Significance	0.39
Standard Error of the Estimate	4.20

The low correlation explains .3 percent of the observed variability and could be attributable to chance 39 percent of the time.

Table 19

Longeot Posttest Versus Potency Posttest

(Experimental)

Correlation	-0.002
r Squared	0.00
Significance	0.50
Standard Error of the Estimate	4.21

A very slight negative correlation exists between the two variables. It is attributable to chance 50 percent of the time.

Table 20

Longeot Posttest Versus Activity Posttest

(Experimental)

Correlation	0.26
r Squared	0.07
Significance	0.08
Standard Error of the Estimate	4.09

The calculated correlation coefficient explains seven percent of the Longeot score variability.

Table 21

Longeot Posttest Versus Evaluation Posttest

(Control)

Correlation	0.34
r Squared	0.19
Significance	0.03
Standard Error of the Estimate	4.22

At first glance, the significance level of the correlation coefficient seemed notable. However, it explained a mere 19 percent of the observed variability. Further, the Standard Error of the Estimate value is close to the Standard Deviation values for the Longeot scores. The conclusion was that there was some relationship between

Longeot posttest scores and Evaluation posttest scores but it was small and would not serve a predictive function.

Table 22

Longeot Posttest Versus Potency Posttest (Control)

Correlation	-0.10
r Squared	0.01
Significance	0.30
Standard Error of the Estimate	4.48

The small negative correlation explains one percent of the Longeot variability.

Table 23

Longeot Posttest Versus Activity Posttest (Control)

Correlation	0.10
r Squared	0.01
Significance	0.30
Standard Error of the Estimate	4.47

The 0.10 correlation is able to predict one percent of the observed variability.

These results led to two conclusions. One, no correlation was established and, two, the course in physical science did not alter the nonexistence of any relationship.

CHAPTER V

POSTSTUDY

The data from the initial study indicated positive attitudes toward science and high cognitive ability with no change due to the experimental treatment. This information is in conflict with previous research and with the personal experiences of the Physics 305 instructors. Subsequently, the validity of the test instruments was determined to be an issue requiring some additional investigation. To pursue this issue a study was carried out in the spring semester (1979), using Physics 305 students as subjects. The purpose of the posttest was twofold. First, to compare data with that gained in the initial study, making it possible to test the validity of the original instruments. Second, to gain more data on the original research questions.

Data Collection

Early in the semester subjects were administered an attitude questionnaire and three Piagetian Tasks. Late in the same semester, subjects were given the Semantic Differential Scale, the Longeot Test and a second attitude scale. The objective data for the experiment are included in Table 24.

First Attitude Questionnaire

This survey contained four questions: (1) What are your general feelings regarding science? (2) What factors have given you this attitude? (3) Have you ever had a successful experience in science? and (4) Do you believe that the study of science is relevant to your present or future needs?

Results--Science Attitude Questionnaire

Thirteen students responded to the first question in a positive manner. Three of the students were seniors, four were juniors and six were in their sophomore year of study. Their comments often related to science being "useful" and "interesting." Some students mentioned that science was stimulating and challenging and that it was good to be knowledgeable about your environment.

When asked what factors had given these attitudes, these students listed:

a. The influence of good instructors
b. good laboratory (hands on) experiences
c. the need to know science because of everyday happenings
d. the enjoyment of teaching young children science.

Factors c. and d. were only mentioned once. Factor b. was mentioned a number of times. However, overwhelmingly the most important factor was the influence of good instructors. Pleasant experiences with their teachers obviously molded the students' concepts of science. All of the students who expressed positive feelings toward science stated that they had had at least one successful experience with it. The experience may have been an activity, a good grade or an interesting teacher, but a distinct correlation existed between successful experience and science attitude. Most of these same students expressed that science was relevant to their present or future needs. Reasons included a need to be knowledgeable on health and technological advances on the energy crisis. Some valued science for its utilitarian application and a few subjects simply viewed science as relating to every aspect of their lives.

Fourteen of the students had mixed feelings regarding science. A few students mentioned that they lacked a positive response to science because of a poor elementary school program. Some students mentioned that they have found science enjoyable but that it resulted in some anxiety. Some mentioned that it was difficult but it was also necessary to learn about new things. One person expressed a fondness of learning "principles," but stated that the work which was involved was unpleasant. Some students expressed a fondness of one area of science, i.e., biology, but a dislike for science overall. As with the positive group, the single most predominant factor affecting attitude was past teachers, whether the teacher was a good or poor instructor. Abstractness, difficulty and boredom were some reasons for negative feelings, while "hands on" experience was a reason for favoring science. In response to the question on successful experiences in science, there was one negative response, one no answer and twelve responses affirming at least one positive experience with science--usually in a course. Without exception, this group believed that science was a subject relevant to their needs. Applications to life in general, to elementary science education and to our technological society were reasons for that feeling. This group with mixed feelings consisted of two seniors, five juniors and seven sophomores.

By far the largest block of students to take the attitude questionnaire expressed very negative sentiments toward science. This group of 23 people consisted of 6 seniors, 1 junior and 16 sophomores. A typical comment was, "I usually dread taking any science course," or ". . . not that thrilled about the subject." One student associated "fear" and "panic" with science and stated that ". . . past experiences have not given me a great deal of background for teaching children." Factors that were listed as contributing to a negative attitude included:

a. poor background experience in science and not enough science involvement
b. too much memorization
c. boring teacher or teacher with a negative attitude
d. the threat of poor grades or other negative experiences

e. it was difficult or hard
f. lack of application to everyday life.

All of these factors were mentioned a few times. Bad teachers and teaching again predominated as the major influences. All but two of these students had had "one" or "a few" successful science experiences but it was clear that these were outweighed by bad experiences. Two students claimed never to have had a successful experience with science and one of these mentioned that her attitude would be the same even if these had been successful experiences. Twenty subjects unequivocally stated that science was a relevant topic. Three students felt it was "sort of" relevant, "not very relevant" or "unimportant, but not indispensable."

Piagetian Tasks

Three Piagetian Tasks were administered to 21 Physics students. The tasks were, in order of presentation: (a) Metal Cylinders (Lawson et al., 1974), (b) a variation on metal cylinders, and (c) Tall-Short (R. Karplus & Peterson, 1970).

Metal cylinders tested a person's ability to exclude irrelevant variables from an experiment. Piaget maintains that this is an earmark of formal thought. Subjects were presented with two graduated cylinders, each filled with water up to 50 ml., as indicated in Figure 11. The test administrator then

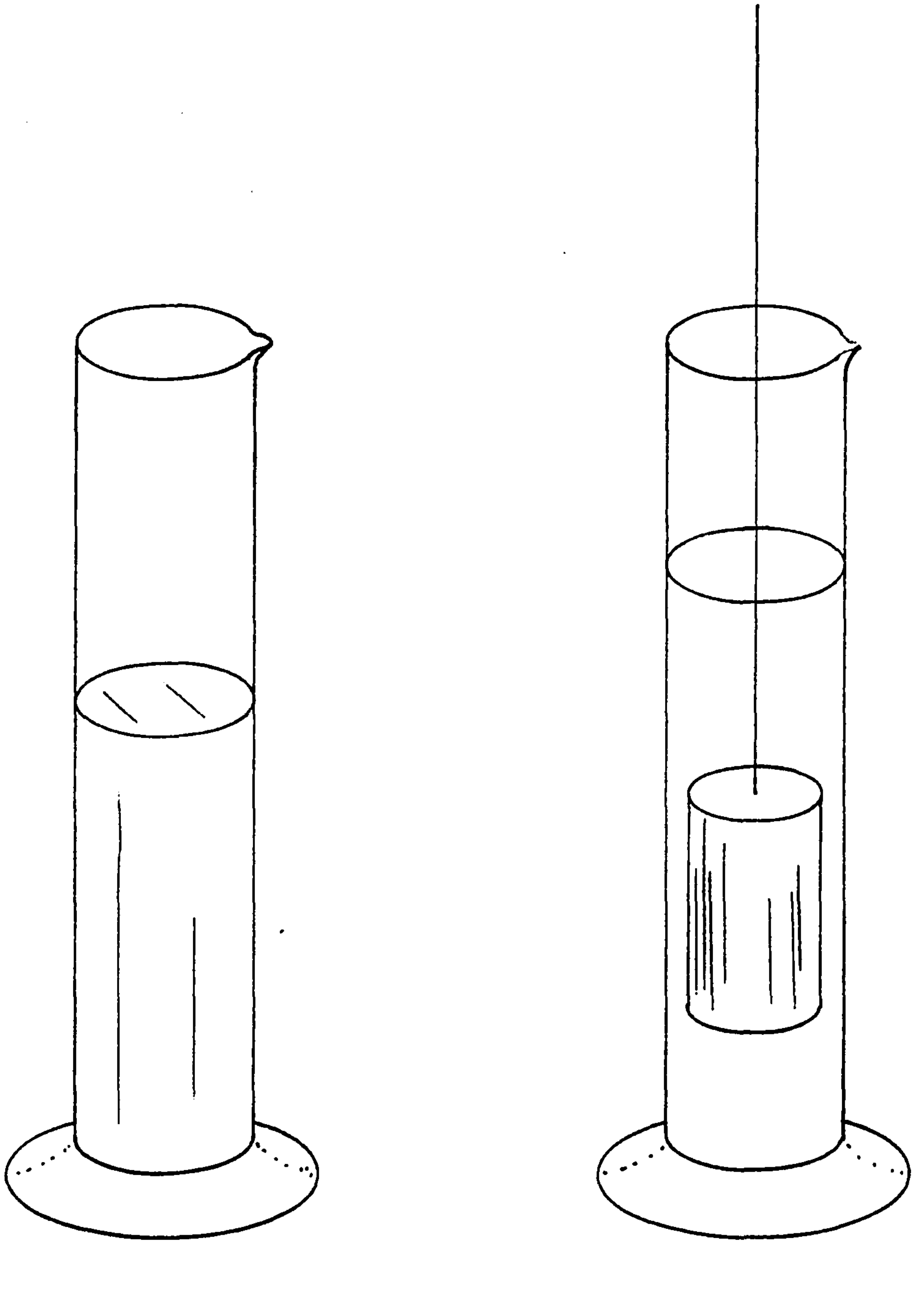

Figure 11. Metal cylinder

showed the subjects two metal cylinders and demonstrated that they were equal in base and height. This was to help the subjects assume equal volume. The subject was then given the cylinders and could easily detect a difference in weight. The subject was next asked to place the lighter metal cylinder into a graduated cylinder. The object would sink and the subject would observe a rise in water level of 10 ml. The question was then asked, "What will happen to the water level in another graduated cylinder when the heavier metal cylinder is placed into it?" After being allowed to respond, the subject submerged the metal cylinder and observed an increase in water level of 10 ml. If this was not in concert with prediction, questions were asked about the experiment. "Can you explain this?" "What do you think happened?" This was to help elicit self-regulation and a partial understanding of what was happening.

Directly after this experiment a second variation of metal cylinders was administered. The same two graduated cylinders (filled to 50 ml) were retained but the subject was presented with new objects to place into the water. Again, the objects were cylindrical and the subject would detect that one was slightly heavier than the other. The subject placed the lighter cylinder into the water and observed that (a) it floated, and (b) the water level rose to 60 ml.

He/she was then asked what would happen when the heavier cylinder would be placed in the water. The subject was informed that the second cylinder would float. After speculating what would happen, the cylinder would be placed into the water. The water rose to approximately 63 ml. The result was discussed with the subject to elicit self-regulation.

Piaget considers the ability to deal with the concept to ratio to be an indication of formal thought. This ability was tested by Mr. Tall-Short. The subject was presented with a stick-figure drawing of Mr. Tall-Short on a card and an attached string of paper clips. The administrator then stated that Mr. Short's height was earlier measured using four large round buttons. On the reverse side of the card was Mr. Tall and his height had been measured at six buttons. The subject was then directed to measure Mr. Short's height using paper clips. The subject would observe him to be six paper clips tall. The question was then asked, "Can you predict the height of Mr. Tall in paper clips?" After the subject made a prediction, the card would be flipped and Mr. Tall was measured to be nine clips. This was discussed with the subject, again, to help elicit self-regulation.

<u>Results (Metal Cylinders-Sinking)</u>

Eight subjects (out of 21) exhibited formal operations ability. They were able to predict that the heavier cylinder would raise the water level 10 ml, the reason being that volume was the only relevant variable. The increased weight was irrelevant. Thirteen subjects predicted that the water level would rise more than 10 ml, "because this cylinder is heavier." After observing that this was not the case, one subject could not explain or understand his/her error. This subject was classified as concrete. Twelve subjects, after some probing ("What do you think happened?"), eventually concluded that weight was not the relevant variable and that volume was. These subjects were demonstrating self-regulation and were presumably between concrete and formal reasoning for this task. Eight students correctly solved the problem, demonstrating formal reasoning.

Results (Cylinders-Floating)

Four subjects predicted that, since the second cylinder was heavier and these cylinders floated, weight was now a critical variable. The prediction was that the water would rise more than 10 ml. These subjects were classified as formal. A total of 17 subjects believed that the water would rise 10 ml only. Upon seeing this error, 4 subjects corrected themselves stating that weight was a relevant variable and should have been considered. These subjects were tagged as exhibiting self-regulation. Thirteen subjects could not understand what was occurring. They could not understand the error of their prediction even with continued probing, discussion and adequate time to contemplate the experiment. These students were grouped as concrete.

The most interesting result of this section can be seen in the profile of results. Fifteen subjects dropped one classification between the first and second metal cylinders tasks. Only one moved up in level and five remained stable. The distinct impression was that the sequence of test administration had a role in this phenomenon. In the first task, all but one subject eventually concluded that weight was not a central variable. Most came to this conclusion with some effort. When these same subjects were forced into a parallel experiment in which weight was a critical variable, they appeared reluctant to consider that complication. Most problem solving is a matter of eliminating irrelevant variables and connecting appropriate data. Perhaps the subjects were reluctant to solve the problem by adding additional variables. The second experiment (very similar to the first) was not approached on an objective basis. Weight was no longer a necessary variable. Since that was true a moment before, it must be true now in very similar circumstances. Many subjects would seemingly wander about searching for a cause. They would look at other inappropriate though obvious differences between these two tasks. An example: "These cylinders are made of wood."

Results (Mr. Tall-Short)

Eleven of the 21 subjects exhibited the ability to deal with ratio and make the proper prediction of a paper clip for Mr. Tall's height. Often these subjects would pause, mumble something about fractions or proportions (2/3 or 1.5). It was clear that they automatically began thinking in appropriate terms. Ten subjects had more difficulty though three of them eventually demonstrated self-regulation. The most common answer among these subjects was eight paper clips. The logic was that, since the height difference was two buttons, it must also be two paper clips, or 6 + 2 = 8. These subjects were at a concrete level since they could only deal with discrete differences and not proportion.

Semantic Differential

The Semantic Differential scale, discussed earlier, was completed earlier in the semester by the Physics 305 students. Forty-seven students were involved. The scores on each dimension are given in Table 25.

Longeot Test

Toward the end of the semester, the Physics 305 students completed Longeot examinations during a scheduled laboratory session. Scoring was performed using the same procedure outlined in the initial study. Scores up to 13 indicated concrete reasoning. Scores of 14 and 15 were

Table 24

Piagetian Tasks

Subjects	Metal Cylinders Sinking	Cylinders Floating	Tall-Short
1	S-R	F	C
2	C	C	F
3	F	C	S-R
4	F	S-R	F
5	S-R	C	F
6	S-R	C	C
7	F	F	C
8	F	C	S-R
9	S-R	C	C
10	F	F	F
11	S-R	S-R	F
12	S-R	C	C
13	S-R	C	F
14	F	F	S-R
15	F	S-R	C
16	S-R	C	F
17	S-R	C	F
18	S-R	C	C
19	S-R	C	F
20	S-R	C	F
21	F	S-R	F
Totals			
	8 F	4 F	11 F
	12 S-R	4 S-R	3 S-R
	1 C	13 C	7 C

F--exhibited formal operations ability
S-R--exhibited self-regulation
C--exhibited concrete operations ability

Table 25

Poststudy: Semantic Differential Scores by Subject

Subjects	Evaluation	Potency	Activity
1	57	13	11
2	61	9	13
3	37	14	7
4	71	12	12
5	64	8	11
6	66	11	8
7	73	10	13
8	65	14	8
9	68	10	8
10	64	10	11
11	47	10	7
12	66	10	9
13	66	10	10
14	47	8	9
15	62	8	11
16	56	9	9
17	30	10	6
18	52	6	9
19	65	8	8
20	60	12	11
21	52	12	13
22	66	11	11
23	73	12	9
24	62	11	14
25	72	3	14
26	62	10	11
27	55	9	9

Table 25 (continued)

Subjects	Evaluation	Potency	Activity
28	57	9	8
29	59	9	10
30	74	14	14
31	58	11	11
32	37	8	10
33	54	12	8
34	58	8	11
35	55	8	9
36	62	8	11
37	57	14	13
38	66	8	10
39	67	12	12
40	63	7	11
41	71	12	14
42	63	11	14
43	61	9	11
44	66	10	10
45	56	12	8
46	56	13	11
47	66	8	11
	Evaluation	Potency	Activity
	Mean=60.10638 Standard Deviation = 9.32093	Mean=10.0638 Standard Deviation = 2.27848	Mean=10.40425 Standard Deviation = 2.08159

transitional scores. A score of 16 or above was an indication of formal reasoning. Forty-eight students participated. All were elementary education majors.

Table 26
Longeot Results: Poststudy

Subjects	Score	Subjects	Score
1	17	25	17
2	27	26	19
3	20	27	19
4	20	28	17
5	27	29	23
6	22	30	23
7	8	31	17
8	23	32	12
9	24	33	20
10	18	34	17
11	22	35	17
12	22	36	18
13	25	37	21
14	25	38	21
15	21	39	23
16	24	40	24
17	26	41	26
18	25	42	26
19	24	43	22
20	21	44	23
21	20	45	19
22	18	46	20
23	22	47	23
24	23	48	9

Three subjects scored as concrete and 45 scored as formal. Students generally did well on syllogistic reasoning (part 1), probabilistic reasoning (part 2) and combinations (part 4). The common weakness was deductive reasoning (part 3).

Attitude Questionnaire

Late in the semester, the same subjects that took the Longeot test also participated in a second attitude questionnaire. Table 27 is a summary of the results of that questionnaire.

Table 27

Results of Second Attitude Questionnaire

First Statement	I have been challenged by the intellectual level of the course.			
Response	Strongly Agree	Agree	Disagree	Strongly Disagree
Number of Responses	21	24	1	1

Second Statement	The information content of the course has been			
Response	Too high	O.K.	Low	Too low
Number of Responses	7	38	0	0

Third Statement	My confidence in teaching science is		
Response	High	O.K.	Low
Number of Responses	8	33	5

Fourth Statement	If you were to rank this course with all other courses you have taken at UNC-G, in terms of educational benefit to you, where would you rank this course, on a scale of one (poorest) to ten (best)? Circle the appropriate number.									
Response	1	2	3	4	5	6	7	8	9	10
Number of Responses	0	0	3	3	1	2	5	18	12	3

Fifth Statement	How has your attitude toward science been affected by this course, if at all?

The responses to Statement Four have a mean of 7.2 (S.D. = 1.86). Some of the comments associated with this high mean were "I learned more in this course than any other," "I can apply learned information to everyday experiences," ". . . lots of helpful hints and ideas (about teaching)," "Very practical--it should be required for all students no matter what their degree is in, this course has helped me to love science" and ". . . this course makes science fun." The students in the course engaged in a weekly experience with elementary students carrying out science activities. Several students mentioned that this portion of the course was very beneficial. The most clearly negative comment (of the few received) stated that the course "lacked the pertinent relativity to children and Physics. Throughout the entire semester, lectures excluded children altogether."

The last question asked of the students related to how their attitudes toward science had been changed by the course. Two students responded that their attitudes were still negative. One student did not respond. Seven responded that the course did not alter their attitude but that it had been positive to start with and still was. This attitude was reinforced in some ways, i.e., the importance of science in society or the enjoyment of seeing children have fun with it. One student stated a positive science attitude concurrent with a negative attitude toward the course. Most of the responses to this question were very positive. Thirty-six students stated, in one way or another, that their attitude toward science was improved--some dramatically. The questionnaires were anonymous but compliments to the instructor were common. There were statements as to how the students now understood that science is vital to children and to society and that it could be fun. Science did not have to be dismally forbidding. A few students stated that the course had improved their science attitude even though their grades in the course were poor. Many claimed that science was now "more interesting."

Positive instructor comments included that the material was well presented in an enthusiastic fashion. Subjects stated that anxiety regarding science and science teaching had been decreased. "I have enjoyed this course more than any other science course." Several stated that the attitude was still "not that great" but that the course had clearly improved it. Two students responded in a direct manner that strikes to the core of this study and speaks strongly for the course.

> This course has helped me to appreciate the importance of teaching science in the elementary schools.
>
> I still find it very difficult; but find myself being angry that I knew absolutely nothing about the concepts until now. That is why it is so hard for me now. For sure--my children will be aware of the concepts of everyday life before they enter college (as they grow everyday, not pushed all at once).

CHAPTER VI

DISCUSSION AND CONCLUSIONS

This study was originally designed to be of a one-semester duration. Tests of cognitive ability and of attitude were administered to a treatment group and to a comparison group as a pretest. After a one-semester physics course was taught to the treatment group, the same tests were again administered to both the treatment and comparison groups. Ultimately, the amount of testing data increased substantially. This occurred because of a prestudy attempt to validate the Longeot instrument and a poststudy designed to resolve new suspicions regarding the Longeot test and the Semantic Differential Scale. The various groups (and subgroups) of test data make possible many cross comparisons. These comparisons lead to some conflicting results. The researcher, therefore, has based his conclusions on the data from the original study as well as a poststudy.

Initial Study

The initial study was as empirical and as controlled as conditions would allow. The design was quasi-experimental and the data were statistically analyzed. The cognitive level (pretest) of both groups was found to be quite high using the Longeot test.

As mentioned, this conflicts with the majority of research cited in Chapter II. Attitude toward science (evaluation, potency and activity) was measured to be higher than previous research would have predicted. This is curious because it is inconsistent with the perceptions of the instructors of the course. Neither the treatment group nor the comparison group demonstrated significant change in any area over the course of the semester. However, since the original scores for cognitive ability, attitude evaluation, attitude potency and attitude activity were quite high, any real change that may have been present may have been masked by ceiling effect. It is clear that further research should be performed on the same research questions but instruments of broader sensitivity should be used. No significant correlation existed between cognitive ability and any of the three attitudinal dimensions. This was true both before and after the course in physical science. The evidence is not sufficient to claim that no relationship exists. First, a relationship could exist that is nonlinear. This would not be detected by the Pearson Product-Moment Calculation. Additionally, ceiling effect would serve to hide even a statistically significant linear relationship. The obvious skewness of many of the attitudinal and cognitive frequency polygons indicates that those distributions are not normal. As a result, the correlation calculation becomes inadequate. Again, research instruments of broader sensitivity should be adapted in further research to find out if attitude and cognitive ability are correlated. This deserves attention since it seems logical that we like what we can do well. Also, it is often presumed that by teaching people to be competent at a skill, we automatically encourage those same people to engage in it. If this is not true, there are some basic fallacies in the education of prospective teachers. Much of that education is directed toward competence in a disciplinary area. Relatively little is concerned with attitude in that area.

Poststudy

The data from the administration of the Piagetian Tasks indicated that most subjects were transitional between concrete and formal operations. This conclusion is in concert with the perception of the Physics 305 laboratory instructor regarding the ability of those students to deal with abstract information. It is in conflict with the Longeot results obtained from testing (a) the same population and (b) an analogous population (original study). The primary conclusion derived from this conflict is that the Longeot test is at least partially inappropriate for testing "Piagetian" cognitive ability with subjects of college age. This is startling because some research (Lawson, 1975, 1976b) has used the test as a primary research instrument. Also, statistical calculations were made from test results.

What are some possible reasons for the dichotomy of Longeot results versus Piagetian Task results? First, the baseline of the Longeot test appears to be too high. This results in a positive skewness of the data and the inappropriate application of statistical technique. Second, students, on the average, are not accustomed to clinical testing. This context may be threatening. On the other hand, most students are very paper and pencil oriented. This may have resulted in some unusually high results. Third, Piaget's model of formal operations ability is very complex. This ability encompasses many subabilities, as described in The Growth of Logical Thinking (Piaget & Inhelder, 1958). Does formal performance in one cognitive area guarantee similar performance in another area? This question of "intersituational generality" has been the object of some research. Inhelder and Piaget contend that the same underlying cognitive matrix is responsible for all the capabilities of formal thought. Piaget does not guarantee that all capabilities will be reached at one particular age, though he does suggest an age range. Neither does he claim that all abilities are reached simultaneously. We are all familiar with the phenomenon of having advanced abilities in some realms and not in others. Are we of formal operations ability in all areas?

Probably not. Certainly familiarity with certain tasks makes us more advanced with similar tasks. This means that most comparative data on cognitive ability are at least partially an "apple and oranges" matter. Note that the three tasks used in the poststudy require exclusion of irrelevant variables and the concept of ratio. The Longeot test requires reasoning through syllogism (Part I), probability (Part II), deductive reasoning (Part III) and combinations (Part IV). Although the same fundamental cognitive structure may be responsible for the correct solution of all "formal" problems, there is no theoretical or experimental evidence that suggests progress in all these areas advances at an identical rate. This is one factor that makes more difficult the interpretation of results from this and many other studies. It is also a factor that raises the question of the validity of studies which compare data on cognitive ability that are reached through different means (different tasks). Note the variance among tasks (same subject) for the Piagetian Tasks in the poststudy. Perhaps what is needed is a more precise definition of cognitive ability. Specific and separate subcategories of cognitive ability would help to avoid some of the confusion.

The poststudy incorporated an original "Piagetian" Task to test formal operations. It is called "floating cylinders." The application and interpretation of floating cylinders has never been discussed. The metal (sinking) cylinder task requires an exclusion of irrelevant variables. This is a formal operations task. Floating cylinders adds a complication to metal cylinders because another variable is incorporated. That is, the experiment is not a simple cause and effect demonstration. A specific combination of two variables is needed to act as a singular causal agent. The subject must seek out various combinations of possible relevant variables and recognize those particular combinations which result in the observed effect. This task was even more difficult in the poststudy because one of these variables was, only seconds before, branded as irrelevant (Metal cylinders).

In floating cylinders, the volumes of the two cylinders are the same and the weights are different. The subject is told that the cylinders will float.

The subject is required to understand that the nature of the masses created a new concept: "effective volume." This nature of the masses includes <u>two facts</u>. The masses are variant and the objects <u>float</u>. These factors are both linked to weight. The simultaneous existence of both factors creates effective volume. The cylindrical volume that sinks below water level is the effective volume and is equal to the volume of water displaced. To interiorize this concept of Archimedes, a person must connect the idea that variant masses and floating objects (results in) new importance of volume (effective volume). This was required of the post-study subjects after they had just eliminated mass as irrelevant (with or without assistance) in the previous experiment. Subjects still had to contend with the presence of irrelevant variables (example: "The cylinders are made of wood.") In a sense this experiment is comparable to a combination of Metal Cylinders (exclusion) and the Balance Beam (combination of relevant variables). This experiment's application to research or formal operations should be studied.

Conclusions

The original study and the poststudy lead us to different conclusions regarding science attitude versus physical science instruction. The original study resulted in high (positive?) attitudes toward science early in the semester without significant change through the semester. The post-study, using an analogous population of subjects, resulted in originally poor science attitudes that improved throughout the semester. The weight of the evidence has led this researcher to place faith in the poststudy results. We can improve the science attitude. However, we may or may not be able to measure that improvement as statistically significant. If so, why the conflicting results of the first study? There are three possible reasons: (1) ceiling effect due to the test instrument; (2) ambiguity of the semantic differential scale results; (3) poor instruction in the laboratory section of the Physics 305 course.

The original scores on the Semantic Differential Scale were fairly high. As with the cognitive ability results, this high mean inevitably results in ceiling effect which makes detection of positive change very difficult. The Semantic Differential may result in unusually positive results. The instructors of those original subjects did not feel that those students had a positive science attitude. Do students interiorize and personalize the questions asked by the Semantic Differential Scale? Is it meaningful to present them with a word (concept), and a bi-polar scale and ask them to quantify their feelings of the scale versus the word? Two problems exist: (1) Does this testing format have real meaning for subjects, and (2) Can people quantify their subjective feelings? This researcher chooses to place his faith in the straightforward and meaningful statements on the attitude questionnaires. I believe that these questions are much more in tune with the subjects' everyday experiences. Hence they have real meaning to the subjects. This results in more personalization of the questions. The subject actually related it to his own experience. Subsequently, a more honest answer was elicited.

The Semantic Differential Scale used incorporated potency and activity scales. What is the meaning of the results of these scales? High results may not necessarily mean positive results. Persons may well think of science as hard and active, but that is not to say pleasant. It seems sensible that those characteristics would not be appreciated by many people. This is particularly true since typical American academic training is a matter of passive reception. Students, accustomed to this method, feel comfortable in courses that require little self-initiated hard work. The high potency and activity scores are a complicating factor. Those data cannot automatically be assumed to reflect positive science attitude.

The third indictment to the original study is the effect of the laboratory instructor's method on the treatment group. Unfortunately, this became a confounding variable. The laboratory section was poorly organized. The same instructor had one lecture section (approximately one-third of the treatment group). Only three or four chapters of the text were discussed. The instructor would often bore the class with three-hour lectures and little student interaction. By the end of the semester, it was obvious that the attitude of the students toward the instructor and the course was negative. The effect on posttesting cannot be estimated, but the mood in that testing session was not constructive to maximizing the power of responses.

These three problem areas were eliminated in the poststudy: straightforward attitudinal questions were asked early and late in the semester. In between, the students engaged in many constructive science activities within an enthusiastic environment. These same students claimed that this resulted in a better feeling about science in general and science teaching in particular. It seems that we can improve science attitude but it is unknown if we can (a) control out all confounding factors, (b) measure attitude using objective scales, and (c) place a statistical value on the increase.

What is clear is that the role of the instructor is critical in helping to improve science attitude. The image of science has remained poor because it is always portrayed as non-interactive and objective. One cannot feel about science or reinterpret it. One cannot grow with it (self-regulation). One can only know it. Scientists are aware that this is not true but the pedagogical methods used on all levels can only have helped to reinforce these beliefs. Hence a major conclusion of this study is that to improve attitudes toward science and the quality of elementary science instruction, prospective teachers need to be exposed to better and more realistic science teaching models.

A key ingredient of this type of instruction is enthusiasm. In the poststudy, comments were made concerning the enthusiasm of the instructor and how this made the students feel good about science. Second, the same students were allowed to model that enthusiasm with students of their own. These young students are naturally curious about the physical world and have not yet been turned off by science memorization and objectivity. The college students were trained to allow the children to interpret the science experiments for themselves. This resulted in a high involvement level and additional enthusiasm. Without a doubt, there are many elementary science teachers that never had a successful science experience but were forced to memorize large amounts of dry data. That being their only perception of science instruction, the same model was used in their elementary classrooms. This resulted in no enthusiasm for science at all and that negative feedback dampened the instructors' desire to initiate further science instruction. Science instruction must be enthusiastic and interactive if it is to result in improved attitudes toward science. The poststudy verifies this fact. Further, science instruction must be interactive if the teacher is interested in aiding cognitive growth. Questions can be asked to help elicit self-regulation and to help develop a questioning approach to science. No evidence exists to prove that memorizing information moves a person into formal operations. If prospective teachers are continually bombarded with inappropriate teaching models, they will continue to assume that these same models are appropriate to elementary instruction.

One illustrative example deserves mention. During the Piagetian Task section of the poststudy, one subject was commenting on an experience she had had, with an elementary student during a recent science session at the school. The prospective teacher was not being successful in teaching the student about some natural phenomenon. Thereupon, she had him memorize an equation which would teach him the "truth" of the experiment. She had always been taught that science truth is often concisely stated in equations. No thought was given to whether a young student could understand an algebraic statement bathed in abstract symbolism and relationships. Paradoxically, that prospective teacher tested out as almost totally at the concrete level, particularly with Mr. Tall-Short. Ironically, Mr. Tall-Short and algebraic language share the need to understand the concept of ratio. Clearly the teacher could not fully understand the same equation she was forcing on the student. She was a product of poor science teaching models that emphasize the veneer of science. She was perpetuating that tradition by acting out the same model in the elementary classroom.

The Piagetian model of cognitive growth is a vastly influential theory in the country today. This, also, is a country that is philosophically oriented to the scientific method. Intrinsic to this method is controlling all confounding variables out of an experiment. Also, the use of high-powered statistics is universally present. The existence of this ethos is understandable since we are steeped in pragmatic tradition and the success of our science and technology speaks for itself. The question that this study leads the researcher to ask is, is the transfer of these techniques to social research in general and to Piagetian theory and attitudinal research in particular valid? It is an old debate. Variables can be controlled out of experiments in the laboratory, so quantifying observations is valid. Science is objective but human beings are very subjective. It is not possible and often not moral to control their variability. The use of adjusting statistics, such as the Analysis of Covariance, cannot completely put a very involved social question back into the laboratory. This researcher noted many difficulties that all social researchers often become victim of: an errant instructor, the psychological effect on the results of a conscripted treatment group versus a volunteer comparison group. Such factors may make an empirical experiment inappropriate. But dropping that model leads to the fear that we are not mathematically certain of our results. If that fear has foundation, how have people ever come to learn in any area other than science? Is all that knowledge invalid? Can we not detect how people feel by what they tell us through questionnaires? Indeed, why the faith in Piaget and his purely clinical technique?

The conclusion is that we do not remain true to a theoretical foundation when we drastically alter the method of testing that theory. If the method is changed, the model is also changed. It may be a disservice to Piaget and his cognitive theory to continue our preoccupation with highly statistical empirical methods. This must be discussed, particularly since the trend continues very strongly in the direction of increased objectivity. Has Piaget intended that his observations of children be graphed and computerized? If researchers do that, do Piaget's theories apply? This researcher will not, cannot, answer this question, but this study indicates that a dialogue on this issue must be opened. That dialogue might also help to explain other discrepancies such as the delayed entry of subjects into formal operations which has been reported by American researchers using statistical methods. Perhaps Paigetian researchers are not measuring the same phenomenon Piaget has observed among Genevan adolescents. Certainly the question of self-regulation and its importance must enter into this dialogue. In summary, more certainty is needed as to the meaning of cognitive ability. Secondly, experimental procedures are needed that do not violate the structure of Piagetian theory. Without that organizational framework, confusion and contradiction will continue to be commonplace in "Piagetian" research.

Major conclusions which can be drawn from this study include:

1. Both attitude toward science and cognitive ability were at low levels among prospective elementary school teachers.

2. Attitude toward science may be improved over the course of a semester and an enthusiastic teacher appears to be an important factor in that change.

3. Cognitive ability was not significantly changed as a result of a one-semester physical science course.

4. There is a need for development of group tests and uniform testing methods for Piagetian research.

5. There is a need for development of standardized terms in Piagetian research.

6. Further research is needed toward an identification of experiences that will enhance the development of cognitive ability.

7. Colleges and universities, in their teacher training programs, should incorporate procedures for identifying and encouraging prospective elementary school teachers who have potential for higher cognitive development in science experiences.

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APPENDIX A

RAVEN'S TEST OF LOGICAL OPERATIONS

APPENDIX C

SEMANTIC DIFFERENTIAL

The purpose of this section of the study is to examine the meaning of a certain concept to various people. On the next page you will find a concept to be judged and, beneath it, a series of descriptive scales. In marking this test, please make your judgments on the basis of what the concept means to you.

Here is how you are to use the scales:

If you feel that the concept is very closely related to one end of the scale, you should place your check-mark as follows:

fair__x__:_____:_____:_____:_____:_____:_____unfair

or

unfair__x__:_____:_____:_____:_____:_____:_____fair

If you consider the concept to be neutral on the scale, both sides of the scale equally associated with the concept, or if the scale is completely irrelevant to the concept, place your check in the middle space:

safe_____:_____:_____:__x__:_____:_____:_____dangerous

The other spaces on the scales can be used when you feel that the concept is moderately related to one end of the scale:

strong _____:_____:__x__:_____:_____:_____:_____ weak

Or more emphatically:

strong _____:_____:_____:_____:_____:__x__:_____ weak

IMPORTANT:

a. Mark each scale.
b. Use only one check-mark per scale.
c. Mark in the middle of the spaces and not on the boundaries.
d. Mark each scale quickly and without thinking of any other scales.

SCIENCE

meaningful	___	___	___	___	___	___	___	meaningless
cruel	___	___	___	___	___	___	___	kind
positive	___	___	___	___	___	___	___	negative
hard	___	___	___	___	___	___	___	soft
bad	___	___	___	___	___	___	___	good
timely	___	___	___	___	___	___	___	untimely
slow	___	___	___	___	___	___	___	fast
wise	___	___	___	___	___	___	___	foolish
true	___	___	___	___	___	___	___	false
humorous	___	___	___	___	___	___	___	serious
painful	___	___	___	___	___	___	___	pleasurable
important	___	___	___	___	___	___	___	unimportant
active	___	___	___	___	___	___	___	passive
beautiful	___	___	___	___	___	___	___	ugly
regressive	___	___	___	___	___	___	___	progressive

APPENDIX D

CORRESPONDENCE

UNIVERSITY OF CALIFORNIA

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LAWRENCE HALL OF SCIENCE
A RESEARCH CENTER IN SCIENCE EDUCATION
(415-642-4193)

BERKELEY, CALIFORNIA 94720

February 10, 1976

Francis X. Nolan
5 Garden Lake Circle
Greensboro, NC 27410

Dear Mr. Nolan:

Enclosed are a number of articles that may be of interest to you with respect to the measurement of formal thought. The difficulty I see with the Karplus measures is their brevity and their focus on only one or two aspects of formal thought. To obtain a reliable measure of formal thought you need a longer and more varied instrument such as the Longeot test mentioned in one of my articles.

Since there is still a good deal of confusion regarding the concept of formal thought, measuring it is no small job. None of the written instruments, in my opinion, are totally satisfactory. For that reason you will simply have to do the best you can with what is available or make up a test yourself.

An English translation of the Longeot examination can be found in a dissertation by D. J. Sheehan, The Effectiveness of Concrete and Formal Instructional Procedures for Concrete and Formal Operational Students, Unpublished doctoral dissertation, State University of New York at Albany, 1970 (University Microfilms #70-25,479, Ann Arbor, Michigan). You will have to write to Albany to find out where Sheehan is now and ask his permission to use the test. You have permission to use the Karplus tests if you like.

Sincerely,

Anton E. Lawson

Anton E. Lawson

AEL:hd
Encls.

STATE UNIVERSITY COLLEGE
ONEONTA, NEW YORK 13820

June 8, 1976

Mr. Francis X. Nolan III
5 Garden Lake Circle
Greensboro, North Carolina 27410

Dear Mr. Nolan:

I apologize for the delay in responding to your letter. The semester did not end until about a week ago and I was very much involved with the necessary responsibilities.

As to your first inquiry- I do not know of anyone who has involved college students with the test. My reaction is why do you have to validate it using college students? The test has been shown to be a reliable instrument for determining stage development of individuals up to a certain age. There is construct validity to the test. And if you can conclude that some college students do not do well on formal-operational tasks then there is reason to believe that the test, with construct validity, will discriminate between concrete-and formal-operational college students. A problem you may have at that level is that you may not find a sufficient number of college students who are concrete-operational to have in your study. In the event that the reasoning that you use in deciding to use the test is not acceptable, then you may have to run a "pilot" of the test. Here are a few references that may help.

1. Beard, Ruth, An Outline of Piaget's Developmental Psychology for Students and Teachers. New York: Basic Books, 1969, p. 113.

2. Piaget, Jean, "Intellectual Evaluation from Adolescence to Adulthood", 3rd International Convention and Awarding of Foneme Prizes. Foneme Institute for Studies and Research in Human Formation, Milan, Italy. May 9-10, 1970, pp. 160-165.

3. McKinnon, Joe W. and Renno, John W., "Are Colleges Concerned with Intellectual Development". American Journal of Psychology, September, 1971, 39, 1047-52.

Your second inquiry is interesting. Why would you treat each section separately? Each section is part of a whole, with the whole test containing items that elicit different types of cognitive development that are consistent with the cognitive characteristics of the two stages. I would therefore treat the test as a whole and not have to average.

There are references in my bibliography to those Longeot articles in which he describes his validation process. The articles are in French, so you will have to translate them. I believe that he used a Guttman model for determining hierarchies. I did not not. Longeot's validation was sufficient, and I obtained a reliability coefficient.

I hope that I have helped in some way. Let me know what you decide to do.

Sincerely yours,

Donald J. Sheehan, Ph.D.
Associate Professor, Education

APPENDIX E

RAW DATA: ORIGINAL STUDY

Table 28

Longeot Test

Experimental Group

Subject	Pretest	Posttest	Difference
1	21	25	+4
2	19	16	-3
3	14	16	+2
4	25	23	-2
5	15	14	-1
6	23	20	-3
7	25	22	-3
8	18	19	+1
9	24	23	-1
10	16	12	-4
11	17	14	-3
12	24	26	+2
13	25	26	+1
14	23	20	-3
15	23	24	+1
16	24	26	+2
17	25	26	+1
18	24	26	+2
19	23	24	+1
20	23	20	-3
21	21	21	0
22	25	25	0
23	18	19	+1
24	22	26	+4
25	17	13	-4
26	26	26	0
27	24	22	-2
28	24	24	0
29	17	21	+4
30	16	21	+5
31	19	20	+1

Table 29

Longeot Test

Control Group

Subject	Pretest	Posttest	Difference
32	21	12	-9
33	21	23	+2
34	24	21	-3
35	19	22	+3
36	21	21	0
37	12	13	+1
38	10	9	-1
39	22	18	-4
40	13	11	-2
41	19	19	0
42	21	23	+2
43	17	19	+2
44	21	19	-2
45	26	25	-1
46	18	20	+2
47	18	23	+5
48	20	26	+2
49	24	26	+2
50	25	21	-4
51	25	26	+1
52	19	23	+4
53	25	22	-3
54	9	14	+5
55	21	16	-5
56	23	19	-4
57	19	17	-2
58	20	18	-2
59	21	25	+4
60	21	21	0
61	16	15	-1
62	21	17	-4

Table 30

Semantic Differential: Potency Scale

Experimental Group

Subject	Pretest	Posttest	Difference
1	12	7	-5
2	9	8	-1
3	5	12	+7
4	8	8	0
5	12	11	-1
6	8	8	0
7	11	10	-1
8	11	9	-2
9	10	13	+3
10	12	11	-1
11	10	11	+1
12	12	9	-3
13	14	14	0
14	14	11	-3
15	8	10	+2
16	12	9	-3
17	14	14	0
18	12	12	0
19	8	10	+2
20	14	11	-3
21	10	10	0
22	8	8	0
23	10	8	-2
24	13	12	-1
25	8	11	+3
26	11	10	-1
27	14	12	-2
28	8	7	-1
29	8	6	-2
30	7	11	+4
31	10	11	+1

Table 31

Semantic Differential: Potency Scale

Control Group

Subject	Pretest	Posttest	Difference
32	11	12	+1
33	11	10	-1
34	12	8	-4
35	12	10	-2
36	12	12	0
37	13	13	0
38	8	9	+1
39	8	7	-1
40	14	11	-3
41	11	10	-1
42	12	12	0
43	8	9	+1
44	11	11	0
45	10	12	+2
46	8	11	+3
47	9	9	0
48	13	12	-1
49	9	9	0
50	14	12	-2
51	12	13	+1
52	10	11	+1
53	11	12	+1
54	11	12	+1
55	11	9	-2
56	11	3	-8
57	7	10	+3
58	7	9	+2
59	8	7	-1
60	14	10	-4
61	13	12	-1
62	12	13	+1

Table 32

Semantic Differential: Activity Scale

Experimental Group

Subject	Pretest	Posttest	Difference
1	13	12	-1
2	11	13	+2
3	8	12	+4
4	9	8	-1
5	8	10	+2
6	14	14	0
7	9	10	+1
8	8	8	+1
9	13	11	-2
10	8	4	-4
11	8	3	-5
12	5	9	+4
13	8	11	+3
14	14	12	-2
15	13	14	+1
16	5	9	+4
17	8	11	+3
18	11	10	-1
19	13	14	+1
20	14	12	-2
21	13	12	-1
22	10	10	0
23	10	8	-2
24	9	10	+1
25	11	10	-1
26	10	10	0
27	8	10	+2
28	8	9	+1
29	8	9	+1
30	8	7	-1
31	13	14	+1

Table 33

Semantic Differential: Activity Scale

Control Group

Subject	Pretest	Posttest	Difference
32	10	12	+2
33	13	11	-2
34	6	9	+3
35	10	12	+2
36	10	9	-1
37	13	12	-1
38	8	10	+2
39	8	4	-4
40	11	8	-3
41	11	6	-5
42	11	10	-1
43	10	9	-1
44	7	8	+1
45	13	9	-4
46	10	12	+2
47	10	9	-1
48	11	10	-1
49	9	11	+2
50	13	14	+1
51	13	12	-1
52	8	12	+4
53	11	11	0
54	7	9	+2
55	8	9	+1
56	8	10	+2
57	11	12	+1
58	11	10	-1
59	10	8	-4
60	13	12	-1
61	10	9	-1
62	9	13	+4

Table 34

Semantic Differential: Evaluation Scale

Experimental Group

Subject	Pretest	Posttest	Difference
1	42	60	+18
2	57	62	+5
3	42	47	+5
4	50	68	+18
5	63	63	0
6	57	56	-1
7	61	51	-10
8	62	64	+2
9	62	58	-4
10	54	44	-10
11	47	47	0
12	50	50	0
13	57	48	-9
14	69	68	-1
15	62	59	-3
16	50	50	0
17	57	48	-9
18	68	64	-4
19	62	59	-3
20	69	68	-1
21	68	59	-9
22	67	57	-10
23	65	72	+7
24	67	52	-15
25	61	53	-8
26	57	59	+2
27	44	68	+24
28	69	69	0
29	56	60	+4
30	48	52	+4
31	49	48	-1

Table 35

Semantic Differential: Evaluation Scale

Control Group

Subject	Pretest	Posttest	Difference
32	55	45	-10
33	61	66	+5
34	54	59	+5
35	58	56	-2
36	68	65	-3
37	53	51	-2
38	61	58	-3
39	44	43	-1
40	56	42	-14
41	59	47	-12
42	63	60	-3
43	60	59	-1
44	58	52	-6
45	68	67	-1
46	54	56	+2
47	52	50	-2
48	60	58	-2
49	55	56	+1
50	53	49	-4
51	62	64	+2
52	56	54	-2
53	56	54	-2
54	52	62	+10
55	62	51	-11
56	42	70	+28
57	57	54	-3
58	60	59	-1
59	52	51	-1
60	53	55	+2
61	61	57	-4
62	54	54	0