COGNITIVE STYLE AND CHILDREN'S PERFORMANCE ON MEASURES OF ELEMENTARY SCIENCE COMPETENCIES

by

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ABSTRACT

The purpose of this exploratory study was to determine the effect of Witkin's construct of cognitive style on children's performance on salient elementary science competencies. These competencies involved the ability to use science processes and the acquisition of specific attitudes.

During the development of the study (see Appendix A), it was first necessary to determine the measurable objectives of the Elementary Science Study (E.S.S.). *The Test of Science Processes* was used to measure those E.S.S. objectives which pertained to science processes. In order to measure the attitudinal objective of the E.S.S. programme, the author developed four attitude scales, utilizing proper attitude measuring techniques. The four scales measured children's attitudes towards the following beliefs: children will feel that "Messing about in Science" is fun (Fun Scale); children will follow-up phenomena encountered during E.S.S. experiences (Pursue Scale); children will impose a structure on their play to find out more (Structure

Scale); children will themselves initiate their own investigations (Independent Investigation Scale). The development of these scales is reported intact in Appendix B. Good reliability and factoral validity were established for these scales. It was hoped that the four attitude scales would prove to be useful tools for elementary science educators.

A natural experiment in a small city school district was utilized to determine the effect of years of E.S.S. experience, the effect of Witkin's construct of cognitive style, and the interaction effect of years of experience with cognitive style -- on children's performance on measures of elementary science competencies. Utilizing a three by three factorial design, the test scores of 184 grade seven pupils were compared. The independent levelling variable used to determine cognitive style was based upon performance on the *Children's Embedded Figures Test* (C.E.F.T.). Years of E.S.S. instruction (one year, two years and three years) comprised the independent blocking variable. Groups were compared on fourteen dependent variables (nine process variables and five attitudinal variables). Hotellings T^2 statistic was computed prior to analysis of variance in order to determine if the global group (C.E.F.T. score 0-15) would achieve significantly lower scores than the analytical group (C.E.F.T. score 20-25) on the sets of elementary science competencies (processes and attitudes).

The predicted inferior performance of the global group was confirmed on the set of attitudinal dependent variables and on the set of dependent variables concerning processes. The predicted effect of superior performance of students who had received more E.S.S. experience than other students was not generally supported by the statistical tests. The predicted interaction effect was not generally significant either, although their appeared to be a trend which might indicate that the global group did less well when this group had more and more E.S.S. experience. Limitations of the cross-sectional design, however, made it difficult to come to any firm conclusions regarding the interaction effect and the effect of years of instruction. Analyses of variance confirmed the findings that the children with a more global cognitive style achieved significantly lower scores on elementary science competencies than children with more analytical cognitive styles.

Based on these findings, the implications of the construct of cognitive style on elementary science education was discussed in terms of methodological reform and curricular reform. Finally, a plan for further research was proposed.

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CHAPTER I

INTRODUCTION

1.0 Importance of the Study

This exploratory investigation focussed on an important issue in curriculum development which was raised more than a decade ago: Shall educators search for the one best curriculum for all children, or shall educators seek to discover which curricula are best suited to children manifesting particular characteristics (Cronbach 1957, 1967; Cronbach and Snow, 1969). Statements such as the following still persist in major elementary science revisions and typify the unilateral approach to curriculum:

> *Every child learns best when real things such as batteries, bulbs, bones and blocks are available for him to use, as tools for his inquiry. As a result, the pupils experience with real things will lead him to search for supporting resources. . . .They* [the pupils] *need to have a free, unstructured period of time to feel, to smell, to listen, etc. . . .How the pupil learns things is more important than the things he learns* (*Elementary Science*, Province of British Columbia, 1969, p. 12).

This statement, though well-intentioned, is questionable and perhaps even contradictory. It is quite possible that when one considers how the pupil learns, it may be that the individual pupil under consideration does not learn best within the structure of the methodology and materials that are prescribed for every child. For example, some children appear to lack direction and to experience great difficulty in the above mentioned elementary school science program which stresses individual, self-initiated experimentation.

The writer does not wish to imply that he is condemning this particular curriculum either. Global condemnation is probably as inappropriate as complete endorsement for all children. Rather, he wishes to emphasize that a curriculum must not be regarded by those in positions of influence as some panacea—some magical elixir which is equally suitable for all children. Clearly, research is called for which attempts to uncover more about the individual differences of children who are learning within the particular framework of a curriculum. The implications of these individual differences and individual styles of dealing with the world should be matched with teaching strategies and curriculum materials. To this effect, this exploratory study attempted to analyze individual differences in terms of the cognitive styles of children who have been experiencing the learning strategies and materials of the Elementary Science Study.

During the development of this research, it was necessary to engage in a parallel study to determine and to develop criterion measures for Elementary Science Study experiences. This parallel research study is reported intact in Appendix A and Appendix B. It is hoped that the attitude scales which were developed by the author will be useful tools for elementary science teachers and for curriculum researchers.

1.1 General Statement of the Problem

a) A Definition of the Construct of Cognitive Style

Witkin (1962) and his associates represent a school of psychology which is called "differential psychology." At the basis of this theory is a concept called field dependence which can be defined as the lack of ability to disembed or to decontextualize a stimulus figure from an irrelevant but organized stimulus background. There is a battery of tests which are used to determine this perceptual ability. For example, in the Rod and Frame Test, a simple square luminous frame provides a field which glows in a semi-darkened room. This frame is pivoted at its center so that a luminous rod may be tilted independently of the frame, clockwise or counterclockwise. The subject is asked to adjust the rod so that its position corresponds to the position of a hypothetical vertical standard ("straight with a flagpole"). Meanwhile the experimenter adjusts the frame to various tilted positions. Some children are able to place the rod in a vertical position without being confused by the surrounding frame. They are able to perceive part of the field as discrete from the dominant part of the visual field. Others seem to rely on the misleading clues of the background to dominate part of the visual field and consequently are referred to as field-dependent, while the former subjects are called field-independent. Subjects at either end of this continuum show a marked degree of consistency in other performance tests which also deal with disembedding one part of a field from the remainder. Figure 1 shows a pair of figures from the *Children's Embedded Figures Test* (Karp and Konstadt, 1969). The subject is asked to find the simple figure on the left within the complex figure on the right. Although this task does not involve perception of the upright, there is a basic commonality between the *Rod and Frame Test* and the *Children's Embedded Figures Test*. In the latter test, a figure is embedded within another and the experimenter attempts to determine how much the dominant whole of the visual field is inhibiting his subject's perception of a part that is embedded within it. Subjects

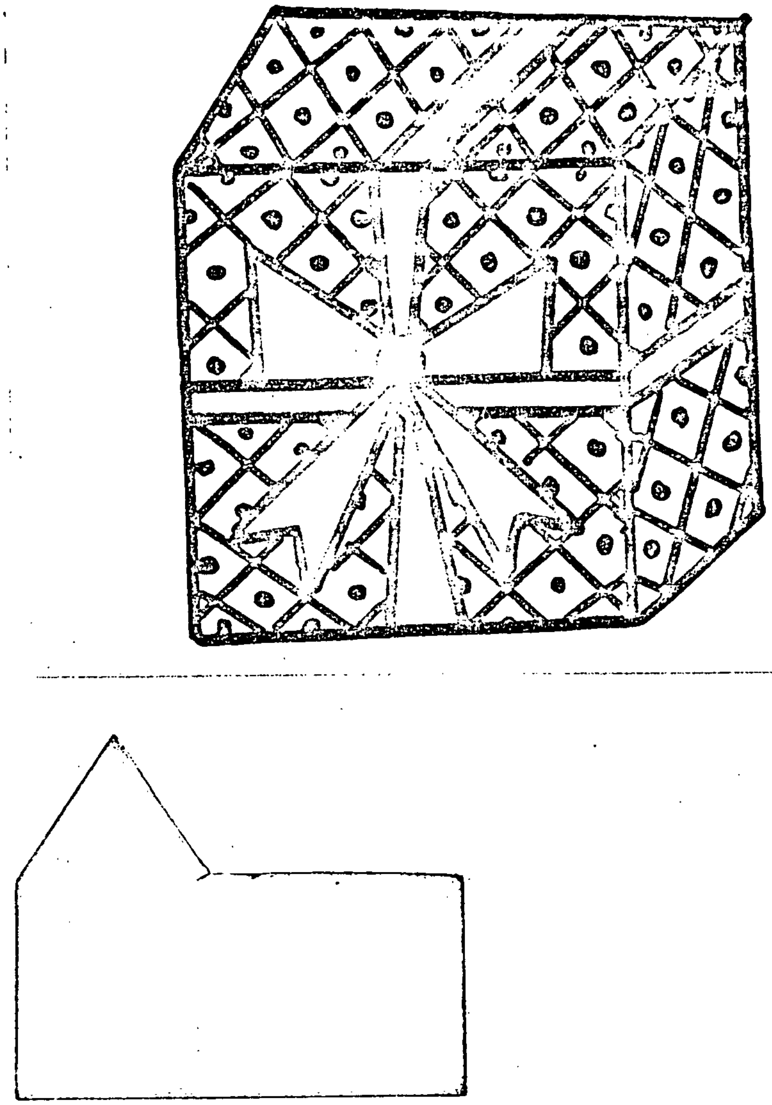

Figure 1

Sample item from the *Children's Embedded Figures Test.*

are trained to find two simple shapes within a more complex background. Then the simple shapes are removed from sight and they are not shown to the subject again unless he requests it; never, however, are both simple shapes and complex shapes presented simultaneously (except in training sessions). As each of the complex shapes is presented, the subject is asked to identify it and name it. In this way, the experimenter is assured that the subject has "taken-in" the whole figure. The subject is then asked to find the simple figure which is embedded within the more complex, misleading figure. The number of correct first responses provides an index of field-independence.

By means of perceptual indices such as these, Witkin and his associates have demonstrated that field dependent children differ from field independent children on a vast number of different criteria such as: dependence on others, the ability to structure ambiguous stimuli, the ability to see alternate uses for the familiar, the ability to resist persuasion by authority, the ability to be logical in the face of evidence that is contrary to the known attitudes of the subjects, and the ability to adopt analytical procedures when dealing with their environment.[1] Witkin summarized these findings and used the term "cognitive style" as it will be used in this study.

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[1]Evidence for this generalization is included in Chapter II which reviews the literature of cognitive style.

To continue with our main story, the studies cited and the numerous other ones as well, have made it quite clear that the style of functioning we first picked up in perception, where we were dealing with an immediately present stimulus configuration, manifests itself as well in intellectual activity, where we are dealing with symbolic functioning. As noted at the outset, we use the designation "cognitive style" to refer to this kind of characteristic, self-consistent way of functioning that an individual shows across perceptual and intellectual (i.e., cognitive) activities. The particular cognitive style we have been discussing, of which field dependence of field independence is the perceptual component, may be described most broadly as follows: at one extreme there is a tendency for experience to be diffuse and global; the organization of a field as a whole dictates the way in which its parts are experienced. At the other extreme the tendency is for experience to be delineated and structured; parts of a field are experienced as discrete and the field as a whole as structured. To these opposite poles of the cognitive style we have applied the labels "global" and "articulated."

It should be emphasized that there is no implication here that the world is populated by two kinds of human beings. Scores for any large group of people on tests of this cognitive style show a continuous distribution and depending on which sides of the mean or average a person's score falls, we say his cognition is more articulated or more global. It is clear from the evidence on hand that a tendency toward a more global or more articulated mode of functioning pervades a child's cognitive activity; and it may be added, on the basis of other evidence, that a given style of cognitive functioning is a stable characteristic of a child even over very long periods of time (Witkin, 1969, p. 206).

b) The Nature of this Study

Utilizing Witkins's construct of cognitive style, this study attempted to demonstrate that the children who could be categorized as being at the extreme ends of the differentiation continuum would achieve significantly different results on elementary science competencies. It was hypothesized that the global group would achieve significantly lower scores than the analytical group on those measures which attempt to tap some of the essential objectives of the Elementary Science Study. Moreover, it was expected that the differences between the global (field dependent group) and the analytical (field independent group) would increase as children had more and more experience within the E.S.S. programme.

CHAPTER II

A REVIEW OF THE LITERATURE ON COGNITIVE STYLE

2.0 The Classical Division between Cognitive Abilities and Perceptual Styles is Unwarranted

A great number of studies have shown that there is a relationship between field dependence and the kinds of attributes which the author believes to be very important in The Elementary Science Study (E.S.S.). There is considerable evidence that the classical division between cognitive abilities and perceptual style is perhaps arbitrary and unwarranted. Differences in perception as measured by the *Embedded Figures Test* (adult version) have been found to be related to differences in cognitive functioning and in particular, to differences in analytical functioning.

Factor analysis has revealed that field dependence, Guilford's construct of adaptive flexibility, Phillip's construct of spatial decontextualization, Dunkcer's notion of functional fixedness, Thurstone's "flexibility of closure," and the construct of "perceptional organization" on the Weschler Intelligence Scale, all involve an ability to disembed (Goodenough and Karp, 1961; Witkin, 1962). Some of the research utilizing Einstellung tests revealed that on the extinction problem (not the critical problems), performance was related to field independence (Guetzkow, 1951, Goodman, 1960). Linton (1952) found field dependence significantly related to logical ability when syllogisms did not conform to the subjects' known views. Eccles (1966) and Pascual-Leone (1968, 1969) have shown that field dependent children are less able to integrate numbers of stimuli. Pascual-Leone believes that field dependence is an intervening variable which may restrict logical functioning (in terms of Pascual-Leone's Information Processing Model). He had demonstrated that many Piagetian situations involve a disembedding ability. Even humour appreciation was investigated and found related to perceptual style (Overlade, 1954, 1955). Evidence suggests also that field independent children tend to experience the world in a clear and structured fashion under everyday situations. Bieri, Bradburn and Galinsky (1958) found field independent children to score higher scores on measures of cognitive clarity.[1]

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[1]This dimension reflects the extent to which information is discrete, structured and assimilated versus blurred, confused and unassimilated (Witkin et. al. 1962, pp. 103-114).

2.1 Cognitive Style is Related to Dependence Upon Others

Of special interest in terms of E.S.S. teaching strategies was the research of Gardner et. al. (1959) and Duram (1964) in which it was revealed that field dependent children learned less in terms of "non-human" incidental learning than did the field independent children, but when the incidental learning material was human faces, this trend was reversed. Gordon (1953) by means of a Thurstone scale, demonstrated that field dependent persons perceived themselves as socially dependent and were judged by others as more dependent as well. Pemberton (1952) in a factor analytic study found that the group which in her terminology corresponded to field dependent classification, tended to be less ambitious, less perservering and less theoretical. Bell (1955) found field dependent subjects more "other directed" than the field independent subjects. Similarly, Frenkel-Brunswick (1949) found that those people who relied on others for guidance tended to show more intolerance for ambiguity in perception. Numbers of studies have related high scores on the F--scale of authoritarianism to field dependence (Pollack et. al., 1960; Jackson, 1955; Linton, 1952). One of Fenchel's (1958) dimensions on his RAPH scale of social rigidity was the belief in "rules for rules sake." This scale was correlated in the expected direction with field dependence. Bales and Couch (1956) showed that men who demonstrated a tendency to accept external authority were more field dependent. A mass of studies has indicated that field dependent people are more easily persuaded by group pressure or external authority (Linton, 1952; Asch, 1956, Crutchfield, 1957; Linton and Graham, 1959).

Many studies indicated that global children would be prone to experience difficulty in unstructured learning situations. From case studies Witkin and his associates found children of "limited differentiation" (global or highly field dependent) to be characterized by the following attributes:

> . . . *poverty of resources, lack of enterprise and initiative, underdeveloped interests, lack of well-structured controls and defenses and marked dependence on others. Children showing this constellation are perhaps the prototype of limitedly differentiated children. A second subgroup showed as an outstanding characteristic severe problems of impulse control though also giving evidence of marked poverty of resources. Finally, the third and smallest subgroup consisted of children whose outstanding characteristic was a high level of verbal skills in the absence of developed unerlying structure. They presented a picture of uneven development*[1] (Witkin, 1962, pp. 268-269).

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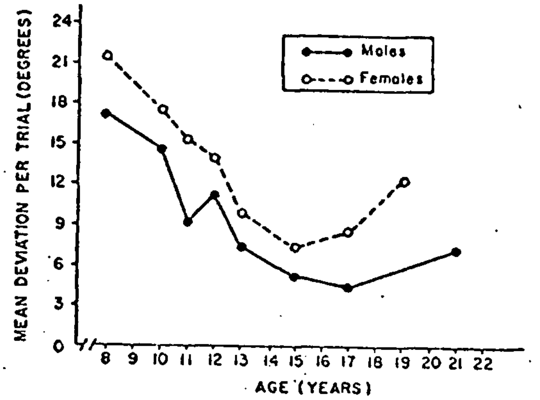
[1]These people could perhaps be called false accomodators in Piagetian sense.

The children described above would quite likely have more difficulty learning situations which call for the child to initiate and carry out his own investigations into phenomena that are revealed to him through play, than those children with many resources at their disposal.

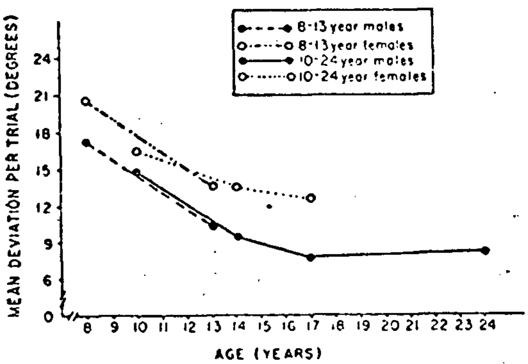
2.2 Studies Reveal the Ontogeny of Differentiation

Some work has been carried out to determine the origins of individual differences in the levels of differentiation. The notion of environmental interaction upon a genetic base has long been a popular view. Vanderberg (cited by Witkin, 1962) studied Rod and Frame Test (R.F.T.) score variation among fraternal and identical twins; results were inconclusive. Perhaps a neurophysical approach to this topic will reveal mechanisms which will account for the disembedding process. J. G. Miller's *The Individual as an Information Processing System* (Fields and Abbot, eds., 1963), provides a basis for interesting speculation about field dependence and differentiation, in terms of neural development and capacity. However, the "nature-nurture" question remains unresolved. Nevertheless, modes of perception have been studied in terms of their stability and in terms of the child-rearing practices of mothers.

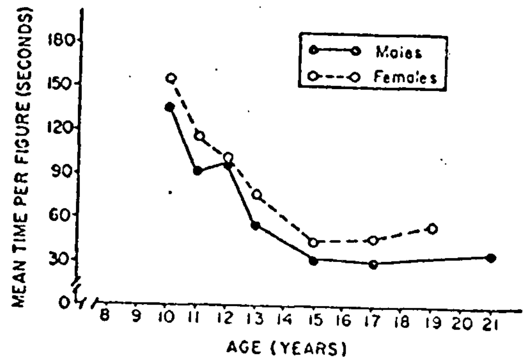
Witkin and his associates (1967) have demonstrated by means of both longitudinal and cross-sectional studies, that the perceptual style of an individual is surprisingly stable. During the growth years, children tend to become more differentiated, but it seems that relative to the group, children remain stable in terms of differentiation. These trends can be seen in the graphs in Figure II.



. Developmental curves for rod-and-frame test based on cross-sectional data.



'. Developmental curves for rod-and-frame test based on longitudinal data.



Developmental curves for embedded-figures test based on cross-sectional data.

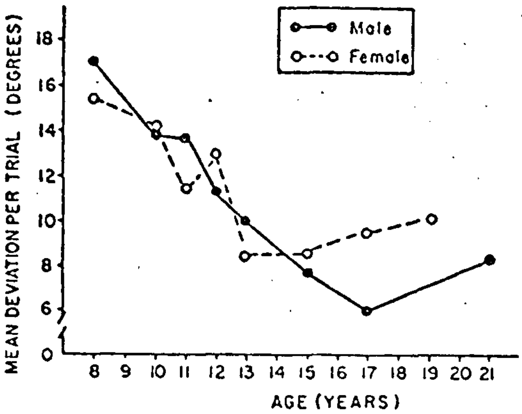


FIG. 1. Developmental curves for body-adjustment test based on cross-sectional data.

Figure II: Stability of Cognitive Style over Time (Witkin, 1967), pp. 295-296)

Fliegel (1955), using college students, found that over a three-year period, test-retest correlations were extremely high on the entire test battery. Franks (1956) utilizing barbituates, amphetimenes, and placeboes, found that perceptual style was remarkably stable after treatment. Of note also is a study by Pollack, Karp and Fink (1960) in which it was found that convulsive therapy tended to reduce field dependence (as cited by Witkin, 1962). These findings suggest that a biophysical mechanism could be involved in the disembedding-analyzing process.

Attempts to change perceptual style of adults via training schedules or via periods of sensory deprivation have not been successful in altering the individual's mode of perception (Witkin, 1948, 1967; Davis, McCourt, and Soloman, 1958; Gruen, 1955). In studies with young people, Witkin, Goodenough and Karp (1961) found that the tendency toward field independence increased generally to about age seventeen and then mode of perception stabilized. Relative to the group however, children remained remarkably stable in mode of perception. Witkin (1967) stated that these stability studies dealt with subjects <u>who themselves were reared in stable family and overall environmental settings</u>. Findings are not as of this time generalizable to unstable environmental child rearing conditions. Nevertheless, one may infer from this literature that if educators wished to alter modes of functioning, the children involved would quite likely have to be quite young.

By means of case studies and interviews, Witkin and his associates found that mothers of undifferentiated children complained often about their husbands and had difficulty themselves coping with everyday-life situations. Mothers of differentiated children tended to be more self-assured and to exhibit a sense of self-realization. In terms of mother-child interaction, mothers of undifferentiated children differed greatly from mothers of differentiated child as a general rule. Undifferentiated children tended to fail to meet the mother's expectations--especially in intellectual achievement, appearance, behavior, and aggression (when agression was directed against the mother). Approval was given on a contingency that the child "be good" and not demanding of care. Mothers of differentiated children tended to be more approving with focus on such things as school achievement, creativity, and the child taking responsibility upon himself. These could be considered to be age-appropriate behaviors. Mothers of analytical children also stimulated curiosity and interest. The former mothers, however, tended to stress conformity, prevented the child's taking-up activities as described above, gave physical care which was not age adequate and often expected adult behavior from their child.

Attempts were made to control children by irrational means and by vacillation from indulgence to severe discipline and to coercion. Other studies showed that mothers of poorly differentiated or global children tended to be more poorly differentiated or global themselves (Witkin, 1962, pp. 286-367).

2.3 Discriminating Attributes of Cognitive Styles are Similar to the Attributes of E.S.S. Activities

Many of the attributes of the kinds of activities that children do in the Elementary Science Study are similar to the attributes on which one can also discriminate between analytic and global children. This similarity is summarized in Table 1 on the following page.

In general there seems to be strong suggestion that the construct of cognitive style is worthy of investigation in terms of science education. If children who are more field dependent do not experience as much success on elementary science competency measures (as defined in Appendix A) then that fact in itself would be worth knowing just from a theoretical point of view. Through the construct of cognitive style teachers could be assisted in identifying these children who experience difficulty working

TABLE 1

A Comparison Showing the Similarity Between E.S.S. Objectives and the Discriminating Attributes of Global *versus* Analytical Functioning

Attributes of E.S.S. objectives	Discriminating attributes of global versus analytical functioning
Attitudes:	
"Messing about" is fun.	Humour appreciation (Overlade)
"Messing about" will lead children to pursue and follow-up phenomena.	Ambition Perserverance (Pemberton) Impulse control (Witkin)
"Messing about" will lead children to impose a structure on their own.	Cognitive clarity (Biera *et. al.*)
"Messing about will lead children to investigate on their own.	Other directedness (Gordon;Bell) Authoritarianism (Pollack) Dependency (Bales and Cooch) Persuasability (Crutchfield)
Science Processes:	
Observing Classifying Analyzing Controlling variables Predicting	Integrating large numbers of stimuli (Pascual-Leone) Intolerance of ambiguity (Frenkel)
Handling data Experimenting Replicating Posing problems Acquiring practical skills	Syllogisms (Linton)
Creative Component:	
free wheeling speculation, creative problem solving, and intuitive, playful exploration.	Insightful thinking (Guetzkow; Goodman)

TABLE 1 (Cont'd.)

Manipulative and building skills.	Two Hand Coordination Test (Podell and Phillips)
Cognitive development:	
Specific concept development.	Incidental learnings (Gardener; Gordon; Duram)
Incidental learnings	

within the curricular framework of the Elementary Science Study. Teachers may be more understanding and may have more empathy with those children referred to above. Because the psychological construct of cognitive style has at its basis a rather well-articulated theory, this theory may be called upon to provide suggestions for specific teaching strategies for these children such as: providing more assistance in ambiguous situations and providing more direction, support, and encouragement for global children. Certainly the theory would suggest that coercive treatment by the teacher would only aggravate the learning situation for global children. In addition the theory would suggest that the initial *laissez faire*, "O" phase of E.S.S. methodology[1] be modified for global children in order that they receive more supportive treatment from the teacher and more encouragement as well. Witkin himself has called for research in education, utilizing his construct of cognitive style.

> *Using this particular cognitive style as a reference let us consider now the ways in which knowledge about the existence of cognitive styles and their specific nature may be useful in dealing with some of the problems encountered in the educational system! In particular, let us examine the implications of the cognitive style work for issues of evaluation, placement and teaching methods. . . .* (Witkin, 1969, pp. 217-218).

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[1]These phases of E.S.S. methodology are described in Appendix B.

Witkin concluded his list of suggested implications for educational research by stating "It must be left to educators to assess the usefulness of these suggestions" (Witkin, 1969, p. 226). In a personal communication with Witkin (January 26, 1970) the author informed him of the general nature of the proposal to use the construct of cognitive style in elementary science education. Witkin replied:

> *I heartily agree with your concept that teaching methods need to be adapted to characteristics of the individual student, rather than applied in the same way to all students. I have long had the feeling, too, that children who are located at different points of the differentiation dimension differ in the teaching approaches they need. I would include under 'teaching approaches' social as well as cognitive aspects of teaching methodology.*

CHAPTER III

PROCEDURES

3.0 A Natural Experiment Existed in a Small-City School District

School District Number 15 (Penticton, B.C.) provided the site and subjects for this study. A natural experiment existed there because the materials and teaching strategies of the Elementary Science Study were being phased-in over a number of years. Consequently, it was possible to locate fairly intact groups of grade seven pupils that had experienced the E.S.S. programme for varying numbers of years. It was a relatively easy task to find classes of children that had had experience with the E.S.S. programme for time intervals of one year, two years, and three years.

Because of pupil mobility, within each class there were a few individuals who had not been the same number of years on the E.S.S. programme as the rest of the group. These children were randomly assigned to one of the other classes which matched their years of E.S.S. experience. Data for pupils whose previous science experience was not known were not included. During the administration of the criterion measures, five of the students moved away, one became seriously ill, and one student died. Students who were temporarily absent from school during the administration of the tests were tested individually upon their return.

Before the testing could begin it was necessary to obtain the cooperation of the school officials and the teachers and pupils of the school district. With the help of the District Superintendent of Schools and the Supervisor of Instruction, principals and teachers were informed about the nature of this investigation.[1] Consequently it was possible to administer the individual and the multiple-sitting group tests in a predetermined schedule.

Testing was carried out in four schools: Snowdon Elementary, O'Connell Elementary, Queen's Park Elementary, and Naramata Elementary. There were two classes with one year of E.S.S. experience; three classes with two years of E.S.S. experience; and two classes with three years of E.S.S. experience. The writer was introduced to each of these classes by the classroom teacher. Each class was

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[1]The supervisor selected classrooms that would be comparable in terms of the teacher variable and he also drafted an affidavit testifying to this effect.

informed that a group of teachers at the university was trying to find out more about ". . . how kids learned science in school." Pupils were told that this group of university teachers was doing an experiment to learn more — just as the students themselves did experiments in science classes. Students were informed that they would be asked to take a number of tests, to respond to a number of quizzes and to solve a number of puzzles. It was emphasized that none of these tasks would be used for report cards and that all of the results would be confidential. Students were generally very interested in participating. During April, May and June of 1970 over two hundred children were tested. It was possible to utilize the data from 184 subjects who met the aforementioned experiential criteria. There were 92 boys and 88 girls in these groups.

3.1 Individual and Group Tests were Administered to the Subjects

All subjects were first given the *Children's Embedded Figures Test* (C.E.F.T.), an untimed, individually administered test. This test provided the independent levelling variable of cognitive style. In general, the protocol utilized for the administration of the test followed the methodology outlined in the test manual. The disembedding process was first introduced in a more casual manner, however. A friendly conversation was initiated which centered about a familiar cartoon figure (Snoopy). Children were then asked to find a simple rectangular figure within the more complex cartoon figure. The experimenter attempted to create an atmosphere in which the subjects were introduced to the task with as little anxiety as possible. Care was taken nevertheless, to have the subjects motivated to do as well as they could on the task. The time to administer the test varied from three to twenty minutes, depending on the subjects.[1]

Following the administration of C.E.F.T. in each of the schools, the attitude scales were administered to each class in two sittings. The four attitude scales attempted to measure the affective objectives of the Elementary Science Study.[2] The attitude scales were administered according to the methodology described in Appendix B. The attitude scales were administered before the rather lengthy *Test of Science Processes* in order to avoid the possibility of the attitude measures becoming contaminated by any hostility

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[1] A more complete introduction to the *Children's Embedded Figures Test* is given on pp. 4-6 above. Item and Test analyses are reported in Appendix C.

[2] The selection of the performance criteria which were used as science competency measures is discussed in Appendix A. Complete details about the development, content, and method of administration of the four attitude scales can be found in Appendix B.

which may have resulted from the administration of the rather difficult process instrument. The four attitude scales provided measures of the first four dependent variables in this study.

Finally, *The Test of Science Processes* was administered to each of the classes in four sittings. Each of the test items was read to the children and then read again, as they themselves read the items. It was the experimenter's intention to attempt to minimize the effect of reading difficulties confounding the process scores. As much time was allowed on each item as the subjects wished. Any reasonable questions about the wording of an item or the nature of the photographs were answered by the experimenter. As with the attitude scales, children responded on standard answer sheets which facilitated machine scoring and data processing. The eight processes measured by this 96 item process instrument provided the remaining dependent variables for this study.

3.2 The Design of this Study can be Categorized as a Factorial Model

The data were classified into a three by three, fixed effects, factorial design. The independent column variables were represented by the number of years the subjects had had

E.S.S. instruction: I, II, III. The independent row variables were represented by three levels of scores determined by the C.E.F.T. performance: 0-15 = global; 16-19 = average; and 20-25 = analytical. These three levels of performance were selected on the basis of the analysis by a computer programme entitled *U.B.C. H-Group*. This program created groups by minimizing the within group variances and maximizing the between group variance. Figure III below represents this design :

	I	II	III
A	32	33	24
B	18	22	20
C	8	15	12

Figure III: The Design of the Study

Columns I, II, and III represent the three levels of E.S.S. experience -- one year, two years and three years respectively. In addition to lending itself to analysis of variance techniques, this model also provided categories for carrying out pre-planned comparisons between levels A and C[1] on the fourteen dependent variables. Rows A, B, and C represent the three levels of C.E.F.T. performance -- the analytic group, the average group and the global group respectively. The figures in each cell represent the number of subjects.

3.3 There was no Significant I.Q. Bias in Columns I, II, and III

It was the original intent of the experimenter to utilize the technique of analysis of covariance to artificially equate the column means of the dependent variables on the basis of I.Q. A more intensive review of the literature on cognitive style revealed however that cognitive style was related to intelligence because the disembedding process was intimately connected with spatial and analytic components of I.Q. tests. The experimenter became concerned about the danger of confounding the effect of cognitive style when covarying on I.Q. In order to determine if the populations represented by the columns in the above design were comparable on I.Q. (*Otis Lennon Quick Score*) a number of statistical tests were completed. A one-way analysis of variance produced an F ratio of 2.53 (probability of .08).

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[1]These comparisons were the basis of hypothesis I and II.

Eta^2 was then calculated from the sums of squares and this statistic revealed that there was no significant relationship between years and I.Q. ($eta^2 = .028$). Jaspens' multiserial correlation also revealed no significant correlation between years and I.Q. ($r = .05$). Furthermore, the complete analyses of variance reported in Chapter IV were re-performed whilst covarying on I.Q. In general the main effect of cognitive style was diluted only slightly by covariance (as theory would suggest), nevertheless the magnitude of the F ratios were still far above the level required for statistical significance in most cases; moreover the F ratios for the main effect of years were virtually unchanged when compared to results from analyses of variance. Hence, it was concluded that there was no significant I.Q. bias in the populations represented by the columns in Figure III. Therefore analysis of variance could be interpreted, minimizing likelihood of I.Q. bias.

3.4 Fourteen Dependent Variables were Tested in the Design

The following dependent variables were found to be suitable criterion measures of Elementary Science Study competencies:[1]

D1 Attitudes concerning the belief that "messing about" is fun.[2]

D2 Attitudes concerning the belief that "messing about" will lead children to pursue (or follow-up) phenomena which are uncovered.

D3 Attitudes concerning the belief that "messing about" will lead children to impose a structure on their play.

D4 Attitudes towards the belief that "messing about" will lead children to investigate on their own.

D5 Total attitudes score towards the belief statements concerning the merits of "messing about" in science (Σ of D_1 to D_4).

D6 Observing - Test of Science Processes (T.O.S.P.).

D7 Comparing - (T.O.S.P.).

D8 Classifying - (T.O.S.P.).

D9 Quantifying - (T.O.S.P.)

D10 Measuring - (T.O.S.P.).

D11 Experimenting - (T.O.S.P.).

D12 Inferring - (T.O.S.P.).

D13 Predicting - (T.O.S.P.).

D14 Total score on all science processes (T.O.S.P.).

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[1]Justification for the selection of these dependent variables as appropriate measures of E.S.S. competencies is given in Appendix A which is exclusively devoted to that task. The attitudes were measured by the author's four scales which are described in detail in Appendix B. The science processes were measured by *The Test of Science Processes*.

[2]The term "messing about" refers to an E.S.S. teaching strategy which is described in Appendix B.

These variables were tested with analysis of variance for the total group and then separately (post-hoc) for the boys and for the girls (Utilizing BMDX 64). t-Tests and Hotelling's T^2 were also used to test the first two hypotheses noted below.

3.5 The Null Hypotheses

When the significance level is set at 5%:

I. There will be no significant difference between the mean scores of the analytical group (level A) and the mean scores of the global group (level C) on the affective measures of elementary science competencies (D1 through D5).

II. There will be no significant difference between the mean scores of the analytical group (level A) and the mean scores of the global group (level C) on the cognitive measures of elementary science competencies (D6 through D14).

III. There will be no significant main effect for years of E.S.S. instruction on each of the fourteen dependent variables.

IV. There will be no significant main effect for cognitive style for each of the fourteen dependent variables.

V. There will be no significant interaction effect between years and cognitive style on each of the fourteen dependent variables.

3.6 The Alternative Hypotheses

When the significance level is set at 5%:

I. There will be a significant difference between the mean scores of the analytical group (level A) and the mean scores of the global group (level C) on the affective measures (D1 through D5), as it is expected that the analytical group will achieve higher scores on these competencies than will the analytical group.

II. There will be a significant difference between the mean scores of the analytical group (level A) and the mean scores of the global group (level C) on the cognitive measures (D6 through D14), as it is expected that the analytical group will achieve higher scores on these competencies than will the global group.

III. There will be a significant main effect for years of E.S.S. instruction on each of the fourteen dependent variables.

IV. There will be a significant main effect for cognitive style on each of the fourteen dependent variables.

V. There will be a significant interaction between years and cognitive style as it is expected that the middle group (level B) and the analytical group (level C) will achieve higher scores with more E.S.S. instruction, but the global group is expected to make less progress or even to regress with more experience on this programme.

CHAPTER IV

THE STATISTICAL ANALYSES

4.0 Raw Data was Analyzed by the Computing Facilities of the University of British Columbia

Group administered tests were scored by the IBM 1232 marking device and made ready for analysis. The results of the C.E.F.T. and *The Test of Science Processes* were then analyzed by utilizing a computer program developed especially for item analysis by the Department of Mathematics Education at U.B.C. This program is entitled *ED46:TIA*. All tests and subtests of these two dichotomously scored instruments were then marked and item analysis was carried out. Point biserial correlations with the test and subtest totals, as well as K.R.-20 internal reliability consistency coefficients for the process instrument and the C.E.F.T. are tabulated in Appendix C. Analyses of the four attitude measures was done by means of specially written computer programs listed at the conclusion of Appendix B. Item analysis was done during final validation procedures, utilizing the output of *U.B.C. Facto.* The results of these analyses of the attitude scales can all be found in Appendix B. After scoring all of the various tests, all of the data were entered on cards in a form acceptable to the analysis of variance program *BMDX64*, and to the *U.B.C. Triangular Regression Package (TRIP)*. The final form of these data is listed in Appendix D.

4.1 Multivariate and Univariate Tests were Utilized for the Statistical Test of Hypothesis I

a). Statistical tests and their Results:

The statistical hypothesis to be tested was the null hypothesis H_0: $\mu_c=\nu_A$ versus the alternative hypothesis H_1: $\mu_c < \nu_A$, where ν represented the population row means of row A and where μ represented the population row means of row C for the set of four affective dependent variables (D1 through D4).

Initially a one-tailed t-test was made to compare the means of the global group with the means of the analytical group on each of the five variables individually. Utilizing the "filter" statements and the "select" statements of the computer program TRIP (U.B.C.'s Triangular Regression Package), the dependent variable scores of those individuals who scored between 0 and 15 on C.E.F.T. were compared to the dependent variable scores of those individuals who scored between 20 and 25 on C.E.F.T. The subroutine t-Test was then employed and the following output was produced:

Table 2

t-Tests Comparing the Global *versus* the Analytical Groups on Each of the the Affective Variables

	Name		Name	t-Value	D.F.	TPROB.	Formula[1]
	Level C:		Level A:				
D1	Funatt	vs.	Funatt	2.152	122	0.016	(3)
D2	Pursue	vs.	Pursue	3.276	122	0.001	(3)
D3	Struct	vs.	Struct	2.282	122	0.0175	(3)
D4	Indexp	vs.	Indexp	3.526	122	0.0005	(3)
D5	Totatt	vs.	Totatt	3.427	122	0.0005	(3)

These individual t-tests appeared to indicate that there was sufficient evidence to reject the null hypothesis for H_{0_1}. With this fairly large number of t-tests, however, there was considerable likelihood of misinterpreting the significance

[1]The formula utilized to obtain t (when population variances were equal) for these comparison was

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

of individual t-values by being overly confident about the probabilities of each individual comparison. Hotelling's T^2 statistic was computed, therefore, to determine if the global versus the analytical criterion would discriminate differences on the affective measures (D1 through D4)[1] when these dependent variables were considered simultaneously. Table 3, on the following page, indicates the results of this multivariate comparison. Hotelling's T^2 was sufficiently large to reject the null hypotheses for H_{0_1}. Further, because the confidence intervals for D2 and D4 did not contain zero, it was statistically justifiable to conclude that the variables D2 and D4 were each, individually sufficient to cause rejection of the null hypothesis for H_{0_1}. Hence the probabilities for D2 and for D4 could be relied upon to be less than .05 when considered independently. The probabilities for D1 and for D3 (reported in Table 2) quite likely could not be relied upon to be less than .05 as Table 2 would suggest. Nevertheless, the difference for D1 and D3 approached statistical significance.

During the analysis that was done to test H_{0_1} it was noticed that there were interesting differences in

[1] D5 (the total attitude scale) had to be eliminated from this multivariate analysis because D5 is a linear combination of other four affective variables. It was felt that the individual t-test probability of D5 could be relied upon because of the magnitude of the t-value and because of the fact that D5 was a linear combination of all the attitude scales (D1 through D4).

Table 3
A Multivariate Comparison of Global *versus* Analytical Groups on the Affective Measures of the Elementary Science Study. Confidence Intervals were Computed at the .05 level (one-tail)

	Level C	Level A	Differences Between Means	Confidence Intervals for Differences Between Means	
	Group 1 Mean	Group 2 Mean		Left Limit	Right Limit
Funatt	49.657	54.629	-4.972	-11.573	1.629
Pursue	43.771	51.719	-7.948	-14.879	-1.016
Struct	38.571	44.640	-6.069	-13.667	1.529
Indexp	38.400	47.449	-9.049	-16.383	-1.716
Data give a Hotelling T-squared value of 15.623 and associated F-value 3.810 which is significant. The computed Probability of this statistic = .0061 compared to Pre-set probability of .05 (one-tail)					
Degrees of freedom — 4 vs. 119					
F-value used in determination — 1.991					

t-values when the total population was divided according to sex and separate analysis done. It would appear that for girls especially, C.E.F.T. score groupings did not discriminate between performances on either D1 or D3 at probability levels that were significant or were approaching significance. This comparison of t-values for sex groupings is summarized below in Table 4.

Table 4

A Comparison of Individual t-Tests of the Total Group versus the t-Tests of Each Sex Separately on the Affective Measures

Variables Names		Both Sexes (122 D.F.)		Boys (67 D.F.)		Girls (53 D.F.)	
	Affective Variable:	*t-value*	*T PROB*	*t-value*	*T-PROB*	*t-value*	*T PROB*
D1	Fun Attitude	2.152	.016	1.823	.0345	1.153	(-) .1265
D2	Pursue Att.	3.276	.001	2.104	.0185	2.607	.0055
D3	Structure Att.	2.282	.0175	2.037	.0265	1.023	(-) .156
D4	Individ. Exper. Att.	3.526	.0005	2.692	.003	2.197	.0155
D5	Total Attitude	3.427	.0005	2.519	.007	2.277	.0175

(-) indicates that this difference not significant near .05 level.

b). Summary of the Statistical Test of H_{0_1}:

Hotelling's T^2 was computed to test the null hypothesis that there would be no significant difference between the mean scores of the analytical group (level A) and the mean scores of the global group (level C) on the affective measures of elementary science competencies. The null hypothesis was rejected. It was found that the global group did significantly less well on the four attitudinal measures. Further, it was found that D2 and D4 were in themselves sufficient to cause rejection of the null hypothesis and that the individual probabilities associated with these two variables could be relied upon to be less than .05. Sex influences were also noted, particularly for the attitudes measured by D1 and D3.

4.2 Multivariate and Univariate Tests were Utilized for the Statistical Tests of Hypothesis II

a). Statistical Tests:

The statistical hypothesis to be tested was the null hypothesis $H_{0_{11}}$: $\mu_c = \nu_A$ versus the alternative hypothesis H_{11}: $\mu_c < \nu_A$, where ν represented the population row means of row A and where μ represented the population row means of row C for the set of eight cognitive (process) variables (D6 through D13).

Initially a one-tailed t-test was utilized to compare the means of the global group (row C) with the means of the analytical group (row A) on each of the processes separately. The results of these individual t-tests are reported below in Table 5:

Table 5
t-tests Comparing the Global versus the Analytical Groups on Each of the Processes

	Level C		Level A				
	Variable	vs.	Variable	t-value	D.F.	t.prob	
D6	Observ	vs.	Observ	5.885	122	0.000	(3)
D7	Compar	vs.	Compar	2.447	122	0.0075	(3)
D8	Classi	vs.	Classi	5.688	122	0.000	(1)
D9	Quanti	vs.	Quanti	5.246	46	0.000	(3)
D10	Measur	vs.	Measur	6.492	122	0.000	(3)
D11	Experi	vs.	Experi	3.057	122	0.0015	(3)
D12	Inferr	vs.	Inferr	5.704	122	0.000	(3)
D13	Predic	vs.	Predic	4.313	93	0.000	(1) 1
D14	Totalp	vs.	Totalp	7.57[illegible]	122	0.000	(3)

1. Note:

(1) $$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}$$ (with unequal population variances)

(3) $$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n + n - 2} + \left[\frac{1}{n_1} + \frac{1}{n_2}\right]}}$$ (with equal populations variances)

Because sex differences were noticed during the statistical test of H_{0_1}, the total population was categorized according to sex and separate analyses were done. For the science processes (unlike the attitudes) there were no marked differences in C.E.F.T.'s discrimination attributable to sex. These statistics are summarized in Table 6 below.

Table 6
A Comparison of Individual t-Tests of the Total Group versus t-Tests of Each Sex Separately on the Cognitive Measures (Processes)

Variables Names	Both Sexes (122 D.F.)		Boys (67 D.F.)		Girls (53 D.F.)	
Cognitive Variables:	t	prob.	t	prob.	t	prob.
D6 Observing	5.885	.000	3.923	.000	4.562	.000
D7 Comparing	2.447	.0075	1.486	.069	1.963	.026
D8 Classifying	5.688	.000	4.602	.000	3.324	.001
D9 Quantifying	5.246	.000	4.170	.000	2.154	.022
D10 Measuring	6.492	.000	5.569	.000	3.864	.000
D11 Experimenting	3.057	.0015	2.087	.0195	2.200	.0155
D12 Inferring	5.704	.000	4.231	.000	3.70	.0005
D13 Predicting	4.313	.000	1.686	.046	4.52	.000
D14 Total Processes	7.574	.000	5.816	.000	4.747	.000

Once again, individual t-test evidence indicated that each individual dependent variable revealed significant differences in the performance of the global group versus the performance of the analytical group. Again, however, it was not possible to rely upon the face value of the probabilities for this large number of t-tests. Hotelling's T^2 was computed for this set of variables too, in order to determine if the global group achieved significantly lower scores than the analytical group on the set of process variables when these dependent variables (D6 through D13) were considered simultaneously.[1] This multivariate test was produced by utilizing the TRIP subroutine entitled HOTEL. Output is summarized below in Table 7.

Table 7
A Multivariate Comparison Between the Global Group and the Analytical Group on the Cognitive Elementary Science Competencies (Processes)

	Group 1 Mean	Group 2 Mean	Confidence Intervals for the Differences Between the Means: Left Limit	Right Limit	Differences Between Means
	Level C	Level A			
D6 Observ	3.886	6.067	-3.600	-0.764	-2.182
D7 Compar	3.143	3.629	-1.247	0.274	-0.486
D8 Classi	7.743	9.809	-3.456	-0.677	-2.066
D9 Quanti	7.542	9.888	-3.784	-0.906	-2.345
D10 Measur	1.400	16.360	-7.882	-2.037	-4.960
D11 Expert	4.400	5.494	-2.464	0.275	-1.094
D12 Inferr	4.857	7.427	-4.293	-0.846	-2.570
D13 Predic	3.486	4.685	-2.462	0.063	-1.200

Data give a Hotelling T-squared value of 68.505 and associated F-value 8.072 which is significant. The computed probability of this statistic is 0.0000 compared with the criteria probability of .05 (one-tail). Degrees of Freedom - 8 vs. 115. F-value used in determination - 1.724.

[1] D14 (Total Processes) had to be eliminated from the computation of T^2 because it was a linear combination of the other variables and hence was inadmissable to Hotel. The probability of D14 could be relied upon in any case, as it is a lineal combination of the eight processes.

Hotelling's T^2 was sufficiently large to reject the null hypothesis for $H_{0_{II}}$. Further, because the confidence intervals for D6, D8, D9, D10, and D12 did not contain zero, it was statistically justifiable to conclude that the variables D6, D8, D9, D10, and D12 were each in themselves sufficient to cause rejection of the null hypothesis for $H_{0_{II}}$. Hence the individual probabilities for these specific variables could be relied upon to be less than .05 when considered as separate entities. The probabilities for D7 and D11 could not be relied upon to be less than .05 as Table 6 might seem to suggest. Nevertheless, the differences for D7 and D11 were approaching significance at the .05 level.

b). Summary of the Statistical Test of $H_{0_{II}}$

Hotelling's T^2 was computed to test the null hypothesis that there would be no significant difference between the mean scores of the analytical group (level A) and the mean scores of the global group (level C) on the set of cognitive measures of elementary science competencies (science processes). The null hypothesis was rejected. It was found that the global group did significantly less well on the eight science processes. Further, it was found that for the tests of Observation, Classification, Quantification, Measuring, and Inferring, these tests were each individually sufficient to cause rejection of the null hypothesis, and that the individual probabilities associated with these variables could be relied upon to be less than .05. No marked sex influences were uncovered for the eight science processes.

4.3 The Statistical Tests of Hypotheses III, IV and V

a) Analysis of Variance Tests of $H_{0_{III}}$, $H_{0_{IV}}$, and H_{0_V}.

During the tests of H_{0_I} and $H_{0_{II}}$, it was observed that the global group achieved significantly lower scores on elementary science competencies than did the analytical group. Moreover, sex differences were found to play some part in determining the significance of the differences for the affective measures. It was considered prudent, therefore to test the three remaining hypotheses, not only for the total sample, but also for boys and for girls separately. The results of these analyses of variance are summarized below in Table 8. Findings are reported for the total group in Table 8a. Table 8b reports findings for the boys and Table 8c reports results for the girls. Because of the extensiveness of these analyses, the acceptance and rejection of particular hypotheses were included as part of the tables referred to. Following these tables a summary of accepted versus rejected hypotheses is also presented in tabular form.

Table 8a

Total Groups' Analyses of Variance Tables

D1. FUN SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	439701.01119	1	439701.00000	3425.18384	
III	Years	175.82117	2	87.91058	0.68481	accept
IV	Cogst	920.97491	2	460.48730	3.58710	reject
V	Cy	281.06846	4	70.26709	0.54737	accept
	Error	22465.27153	175	128.37296		

D2. PURSUE SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	368982.75732	1	368982.750000	2125.11768	
III	Years	11.55316	2	5.77658	0.03327	accept
IV	Cogst	1552.10600	2	776.05298	4.46960	reject
V	Cy	418.24636	4	104.56158	0.60221	accept
	Error	30385.13441	175	173.62932		

D3. STRUCTURE SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	284245.60927	1	284245.46250	1549.29395	
III	Years	18.19544	2	9.09772	0.04959	accept
IV	Cogst	970.19061	2	485.09521	2.64403	accept(+)[1]
V	Cy	333.87566	4	83.46887	0.45495	accept
	Error	32106.86338	175	183.46779		

Note: [1](+) = approaching significance at $\alpha = .05$.

D4. INDIVIDUAL EXPERIMENTATION

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	295076.60211	1	295076.56250	1669.96802	
III	Years	186.68892	2	93.34445	0.52828	accept
IV	Cogst	1723.10846	2	861.55420	4.87591	reject
V	Cy	290.41381	4	72.60339	0.41089	accept
	Error	20921.79047	175	176.69592		

D5. TOTAL ATTITUDES TOWARDS MESSING ABOUT IN SCIENCE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	5506305.52455	1	5506305.00000	3020.86548	
III	Years	378.31424	2	189.15710	0.10378	accept
IV	Cogst	19480.75916	2	9740.37891	5.34376	reject
V	Cy	1994.77889	4	498.69456	0.27359	accept
	Error	318982.60941	175	1822.75732		

D6. OBSERVING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	3862.36532	1	3862.36523	1165.75171	
III	Years	25.09983	2	12.54991	3.78786	reject
IV	Cogst	101.54618	2	50.77309	15.32450	reject
V	Cy	11.35123	4	2.83781	0.85652	accept
	Error	579.80960	175	3.31320		

D7. COMPARING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	1772.53103	1	1772.53101	1685.45752	
III	Years	1.71745	2	0.85873	0.81655	accept
IV	Cogst	6.28930	2	3.14465	2.99017	accept(+)
V	Cy	0.70462	4	0.17615	0.16750	accept
	Error	184.04091	175	1.05166		

D8. CLASSIFYING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_o
	Mean	12233.92816	1	12233.92578	4087.74048	
III	Years	3.37249	2	1.68624	0.56343	accept
IV	Cogst	95.06451	2	47.53224	15.88202	reject
V	Cy	31.26261	4	7.81565	2.61145	reject
	Error	523.74596	175	2,99283		

D9. QUANTIFYING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_o
	Mean	12129.96730	1	12129.96484	3769.07544	
III	Years	8.25529	2	4.12764	1.28256	accept
IV	Cogst	122.98666	2	61.49322	19.10747	reject
V	Cy	20.71625	4	5.17906	1.60926	accept
	Error	563.20032	175	3.21829		

D10. MEASURING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_o
	Mean	29635.34867	1	29635.34766	1963.31738	
III	Years	105.23352	2	53.61676	3.48582	reject
IV	Cogst	634.96289	2	317.48120	21.03287	reject
V	Cy	61.75043	4	15.43760	1.02273	accept
	Error	2641.54223	175	15.09453		

D11. EXPERIMENTING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_o
	Mean	3638.34347	1	3638.34326	1101.12793	
III	Years	7.18945	2	3.59473	1.08793	accept
IV	Cogst	37.41347	2	18.70677	5.66152	reject
V	Cy	15.17475	4	3.79369	1.14814	accept
	Error	578.23441	175	3.30420		

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
		D12. INFERRING				
	Mean	5976.04107	1	5976.03906	1193.24414	
III	Years	30.50133	2	15.25066	3.04512	reject
IV	Cogst	158.01676	2	79.00838	15.77572	reject
V	Cy	5.19325	4	1.29831	0.25924	accept
	Error	876.44015	175	5.00823		
		D13. PREDICTING				
	Mean	2722.50407	1	2722.50391	1073.22925	
III	Years	0.55284	2	0.27642	0.10897	accept
IV	Cogst	34.45086	2	17.22542	6.79037	reject
V	Cy	3.72862	4	0.93215	0.36746	accept
	Error	443.92986	175	2.53674		
		D14. TOTAL SCIENCE PROCESSES				
	Mean	471890.62186	1	471890.56250	3957.72778	
III	Years	512.62593	2	256.31274	2.14968	accept(+)
IV	Cogst	6769.76153	2	3384.87891	28.38884	reject
V	Cy	428.12938	4	107.03229	0.89768	accept
	Error	20865.72399	175	119.23270		

F values required for rejection of H_o:

Df.	α.10	α.05	α.01
2 vs. 175	2.30	3.00	4.61
4 vs. 175	1.94	2.37	3.32

Table 8b

Boys' Analyses of Variance Tables

D1. FUN SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_o
	Mean	233838.13303	1	233838.12500	1777.18140	
III	Years	94.19879	2	47.09940	0.35796	accept
IV	Cogst	729.87535	2	364.94750	2.77354	accept (+)
V	Cy	434.34932	4	108.58728	0.82527	accept
	Error	11447.29659	87	131.57808		

D2. PURSUE SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_o
	Mean	192378.15216	1	192378.12500	1087.43848	
III	Years	129.11036	2	64.55518	0.36491	accept
IV	Cogst	1890.11850	2	945.05908	5.34205	reject
V	Cy	808.34525	4	202.08630	1.14231	accept
	Error	15391.12160	87	176.90942		

D3. STRUCTURE SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_o
	Mean	146585.84323	1	146585.81250	723.72192	
III	Years	59.27946	2	29.63972	0.14634	accept
IV	Cogst	1355.96059	2	677.98022	3.34732	reject
V	Cy	132.54475	4	33.13618	0.16360	accept
	Mean	17621.36215	87	202.54436		

BOYS (Cont'd)

D4. INDIVIDUAL EXPERIMENTATION SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	16294.81453	1	162694.81250	932.93555	
III	Years	386.74678	2	193.37329	1.10885	accept
IV	Cogst	1716.76755	2	858.38354	4.92220	reject
V	Cy	684.53738	4	171.13434	0.98133	accept
	Error	15171.94799	87	174.39017		

D5. TOTAL ATTITUDE TOWARD "MESSING ABOUT"

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	2918621.07862	1	2918621.00000	1447.76831	
III	Years	1197.47363	2	598.73657	0.29700	accept
IV	Cogst	21883.99120	2	10941.99219	5.42772	reject
V	Cy	175387.20713	4	2015.94458	0.61057	accept
	Error	175387.20713	87	2015.94458		

D6. OBSERVING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	2110.09156	1	2110.09155	586.45752	
III	Years	27.75577	2	13.87788	3.85708	reject
IV	Cogst	33.52035	2	16.76016	4.65815	reject
V	Cy	27.20047	4	6.80012	1.88996	accept
	Error	313.02880	87	3.59803		

D7. COMPARING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	904.15951	1	904.15942	736.23315	
III	Years	0.60633	2	0.30317	0.24686	accept
IV	Cogst	1.89718	2	0.94859	0.77241	accept
V	Cy	0.84639	4	0.21160	0.17230	accept
	Error	106.84375	87	1.22809		

BOYS (Cont'd)

D8. CLASSIFYING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	6062.16458	1	6062.16406	2068.88110	
III	Years	3.42785	2	1.71393	0.58492	accept
IV	Cogst	50.11094	2	25.05547	8.55087	reject
V	Cy	29.55982	4	7.38995	2.52203	reject
	Error	254.92441	87	2.93017		

D9. QUANTIFYING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	6205.42328	1	6205.42188	1989.42993	
III	Years	6.65426	2	3.32713	1.06666	accept
IV	Cogst	86.65572	2	43.32785	13.89071	reject
V	Cy	29.68223	4	7.42056	2.37900	accept(+)
	Error	271.37018	87	3.11920		

D10. MEASURING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	16816.69776	1	16816.69531	1193.97412	
III	Years	32.53012	2	16.26506	1.15481	accept
IV	Cogst	306.90663	2	153.45325	10.89508	reject
V	Cy	88.38174	4	22.09543	1.56876	accept
	Error	1225.36373	87	14.08464		

D11. EXPERIMENTING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	1772.25667	1	1772.25659	495.34985	
III	Years	2.35120	2	1.17560	0.32858	accept
IV	Cogst	17.86458	2	8.93229	2.49660	accept(+)
V	Cy	8.14008	4	2.03502	0.56879	accept
	Error	311.26777	87	3.57779		

BOYS (Cont'd)

D12. INFERRING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_o
	Mean	2908.82763	1	2908.82739	542.48350	
III	Years	7.48507	2	3.74253	0.69797	accept
IV	Cogst	73.88997	2	36.94498	6.89007	reject
V	Cy	12.34654	4	3.08663	0.57564	accept
	Error	466.49914	87	5.36206		

D13. PREDICTING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_o
	Mean	1394.64486	1	1394.64478	554.35938	
III	Years	3.84833	2	1.92416	0.76484	accept
IV	Cogst	6.28463	2	3.14232	1.24904	accept
V	Cy	5.10169	4	1.27542	0.50697	accept
	Error	218.87265	87	2.51578		

D14. TOTAL PROCESSES

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_o
	Mean	245712.80379	1	245713.75000	2040.54761	
III	Years	223.51510	2	111.75754	0.92810	accept
IV	Cogst	2930.68879	2	1465.34424	12.16906	reject
V	Cy	723.62113	4	180.90527	1.50234	accept
	Error	10476.15713	87	120.41559		

F values required for rejection of H_o:

Df.	α.10	α.05	α.01
2 vs. 87	2.37	3.15	4.98
4 vs. 87	2.05	2.53	3.65

Table 8c

Girls' Analyses of Variance Table

D1. FUN SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	193423.48986	1	193423.43750	1530.63770	
III	Years	482.59342	2	241.29663	1.90948	accept
IV	Cogst	328.65358	2	164.32678	1.30038	accept
V	Cy	363.13841	4	90.78455	0.71841	accept
	Error	9983.06445	79	126.36787		

D2. PURSUE SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	165693.71054	1	165693.68750	1070.15430	
III	Years	333.06169	2	166.53076	1.07556	accept
IV	Cogst	1081.66355	2	540.83154	3.49303	reject
V	Cy	790.01929	4	197.50482	1.27561	accept
	Error	12231.69907	79	154.83157		

D3. STRUCTURE SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	129091.89722	1	129091.87500	752.33862	
III	Years	5.82983	2	2.91492	0.01699	accept
IV	Cogst	128.16886	2	64.08443	0.37348	accept
V	Cy	713.60288	4	178.40070	1.03971	accept
	Error	13555.40699	79	171.58742		

D4. INDIVIDUAL EXPERIMENTATION SCALE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	127259.35428	1	127259.31250	740.66821	
III	Years	8.45721	2	4.22861	0.02461	accept
IV	Cogst	981.82155	2	490.91064	2.85717	accept(+)
V	Cy	314.55069	4	78.63763	0.45768	accept
	Error	13573.53462	79	171.81685		

D5. TOTAL ATTITUDE TOWARD "MESSING ABOUT" IN SCIENCE

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	2440425.93034	1	2440425.00000	1552.68945	
III	Years	1990.16335	2	995.08154	0.63311	accept
IV	Cogst	7408.92599	2	3704.46289	2.35692	accept(+)
V	Cy	4297.74115	4	1074.43457	0.68360	accept
	Error	124167.55420	79	1571.74048		

D6. OBSERVING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	1594.21551	1	1594.21533	559.45532	
III	Years	17.56233	2	8.78116	3.08156	reject
IV	Cogst	74.57972	2	37.28955	13.08596	reject
V	Cy	13.35016	4	3.33754	1.17124	accept
	Error	225.11713	79	2.84958		

D7. COMPARING

Hypo.	Source	Sum of Squares	D.F.	Mean Square	F	H_0
	Mean	807.68098	1	807.68091	893.91797	
III	Years	1.54633	2	0.77316	0.85572	accept
IV	Cogst	4.80940	2	2.40470	2.66145	accept(+)
V	Cy	3.87694	4	0.96923	1.07272	accept
	Error	71.37879	79	0.90353		

D8. CLASSIFYING

Hypo.	Source	Sum of Squares	D.F.	Mean Squares	F	H_0
	Mean	5770.62647	1	5770.62500	1872.84473	
III	Years	1.09216	2	0.54608	0.17723	accept
IV	Cogst	49.23180	2	24.61589	7.98904	reject
V	Cy	15.19630	4	3.79907	1.23298	accept
	Error	243.41550	79	3.08121		

D9. QUANTIFYING

	Mean	5558.63155	1	5558.62891	1653.35815	
III	Years	2.54197	2	1.27099	0.37804	accept
IV	Cogst	29.55254	2	14.77627	4.39505	reject
V	Cy	4.33905	4	1.08476	0.32265	accept
	Error	265.60000	79	3.36202		

D10. MEASURING

	Mean	11900.29503	1	11900.29297	767.10522	
III	Years	87.58741	2	43.79370	2.82299	accept
IV	Cogst	323.79244	2	161.89612	10.43599	reject
V	Cy	53.71161	4	13.42790	0.86558	accept
	Error	1225.54662	79	15.51324		

D11. EXPERIMENTING

	Mean	1727.00083	1	1727.00073	529.33911	
III	Years	8.87023	2	4.43511	1.35940	accept
IV	Cogst	20.68681	2	10.34340	3.35940	reject
V	Cy	10.09581	4	2.52395	0.77361	accept
	Error	257.74231	79	3.26256		

D12. INFERRING

Hypo.	Source	Sum of Squares	D.F.	Mean Squares	F	H_0
	Mean	2928.79588	1	2928.79565	620.17139	
III	Years	36.20162	2	18.10080	3.83284	reject
IV	Cogst	75.01964	2	37.50981	7.94269	reject
V	Cy	11.34160	4	2.83540	0.60039	accept
	Error	373.08217	79	4.72256		

D13. PREDICTING

Hypo.	Source	Sum of Squares	D.F.	Mean Squares	F	H_0
	Mean	1249.36653	1	1249.36646	501.94800	
III	Years	8.35602	2	4.17801	1.67857	accept
IV	Cogst	38.78139	2	19.39069	7.79044	reject
V	Cy	5.02702	4	1.25674	0.50492	accept
	Error	196.63380	79	2.48903		

D14. TOTAL SCIENCE PROCESSES

Hypo.	Source	Sum of Squares	D.F.	Mean Squares	F	H_0
	Mean	210661.38328	1	210661.37500	1758.59546	
III	Years	657.75766	2	328.87866	2.74547	accept
IV	Cogst	3637.19460	2	1818.59717	15.18160	reject
V	Cy	491.02467	4	122.75616	1.02477	accept
	Error	9463.37879	79	119.78955		

F values required for rejection of H_0:

Df.	α.10	α.05	α.01
2 vs. 79	2.39	3.15	4.98
4 vs. 79	2.04	2.53	3.65

b). Summary of Tests of Hypotheses III, IV, and V.

Table 9 below indicates those specific null hypotheses which were accepted versus those null hypotheses which were rejected:

Table 9

Summary of Rejected and Accepted Hypotheses ($H_{0_{III}}$, $H_{0_{IV}}$ and H_{0_V})

	FUN ATT.	PURS ATT.	STR ATT.	INDIV. ATT.	TOTAL ATT.	OBSERVING	COMPARING	CLASSIFYING	QUANTIFYING	MEASURING	EXPERIMENTING	INFERRING	PREDICTING	TOTAL PROC.
	D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	D 9	D 10	D 11	D 12	D 13	D 14
Main E. YEARS:														
TOTAL	A	A	A	A	A	R	A	A	A	R	A	R	A	A^+
BOYS	A	A	A	A	A	R	A	A	A	A	A	A	A	A
GIRLS	A	A	A	A	A	R	A	A	A	A	A	R	A	A
COG. ST.														
TOTAL	R	R	A^+	R	R	R	A^+	R	R	R	R	R	R	R
BOYS	A^+	R	R	R	R	R	A	R	R	R	A^+	R	A	R
GIRLS	A	R	A	A^+	A^+	R	A^+	R	R	R	R	R	R	R
INTERACTION CY														
TOTAL	A	A	A	A	A	A	A	R	A	A	A	A	A	A
BOYS	A	A	A	A	A	A	A	R	A^+	A	A	A	A	A
GIRLS	A	A	A	A	A	A	A	A	A	A	A	A	A	A

$^+$ = approach significance at $\alpha = .05$

R = significant beyond α.05

Total Number of Rejected H_o's: Main E. Years: 6/42
COG. ST. : 31/42
INTERACTION : 2/42

b-1) The Main Effect for Years of E.S.S. Instruction ($H_{0_{III}}$):

In general, the main effect for years of instruction was only significant in six of forty-two tests. When data from these significant main effects were plotted (see Fig. IV), there were no clear-cut, obvious increases in scores attributable to years of E.S.S. experience. In general: the main effect of years of E.S.S. experience was not significant.

b-2) The Main Effect for Cognitive Style ($H_{0_{IV}}$):

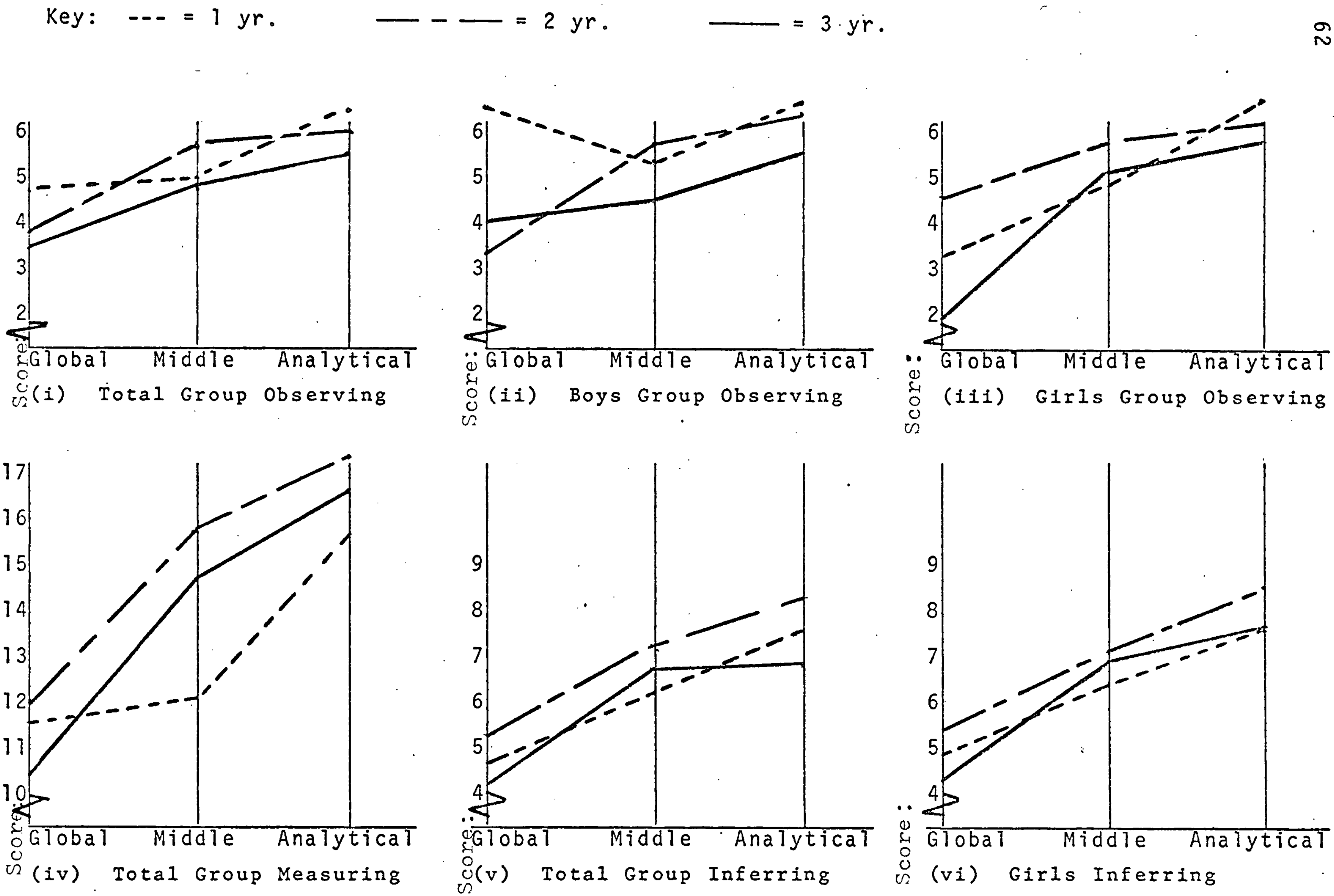
Table 9 indicates that there was a general rejection of the null hypothesis for $H_{0_{IV}}$. The main effect of cognitive style was significant in all but two variables for the total group. In these two exceptions, the F ratios were approaching significance at the .05 level. This general rejection of the null hypothesis for $H_{0_{IV}}$ was consistent with the findings for H_{0_I} and $H_{0_{II}}$.

Sex differences were observed which were consistent with the findings for H_{0_I} and $H_{0_{II}}$ as well. Worthy of emphasis was the finding that the main effect of cognitive style was not significant for the girls when the means were compared for D1 (the Fun Scale) and for D3 (the Structure Scale).

b-3) The Interaction Effect of Cognitive Style and Years of E.S.S. Experience (H_{0_V}):

Only two of forty-two interaction effects were statistically significant. These two significant interactions can be seen visually in Figure V. Certainly two significant interactions out of a possible forty-two significant interaction effects, did not provide sufficient evidence to reject the null hypothesis for H_{0_V}. In general it was necessary to accept this null hypothesis.

Fig. IV: All Significant Main Effects for Years of E.S.S. Experience



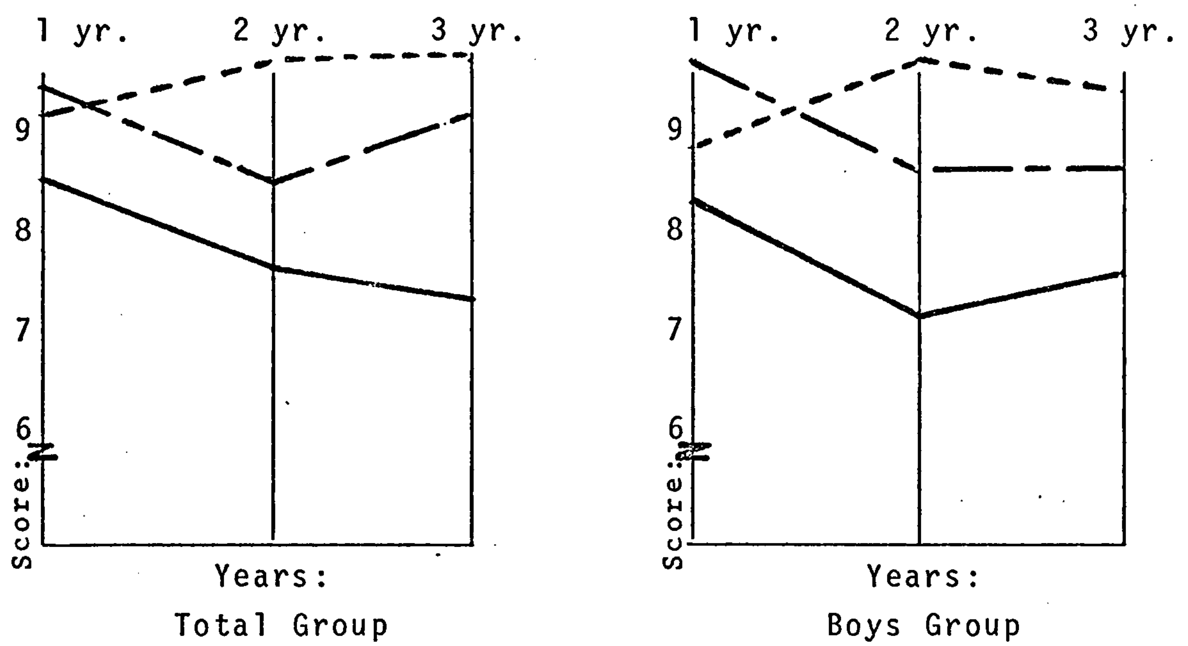


Fig. V: Statistically Significant Interactions: Classifying

Key: --- = analytical

— — — = average group

——— = global group

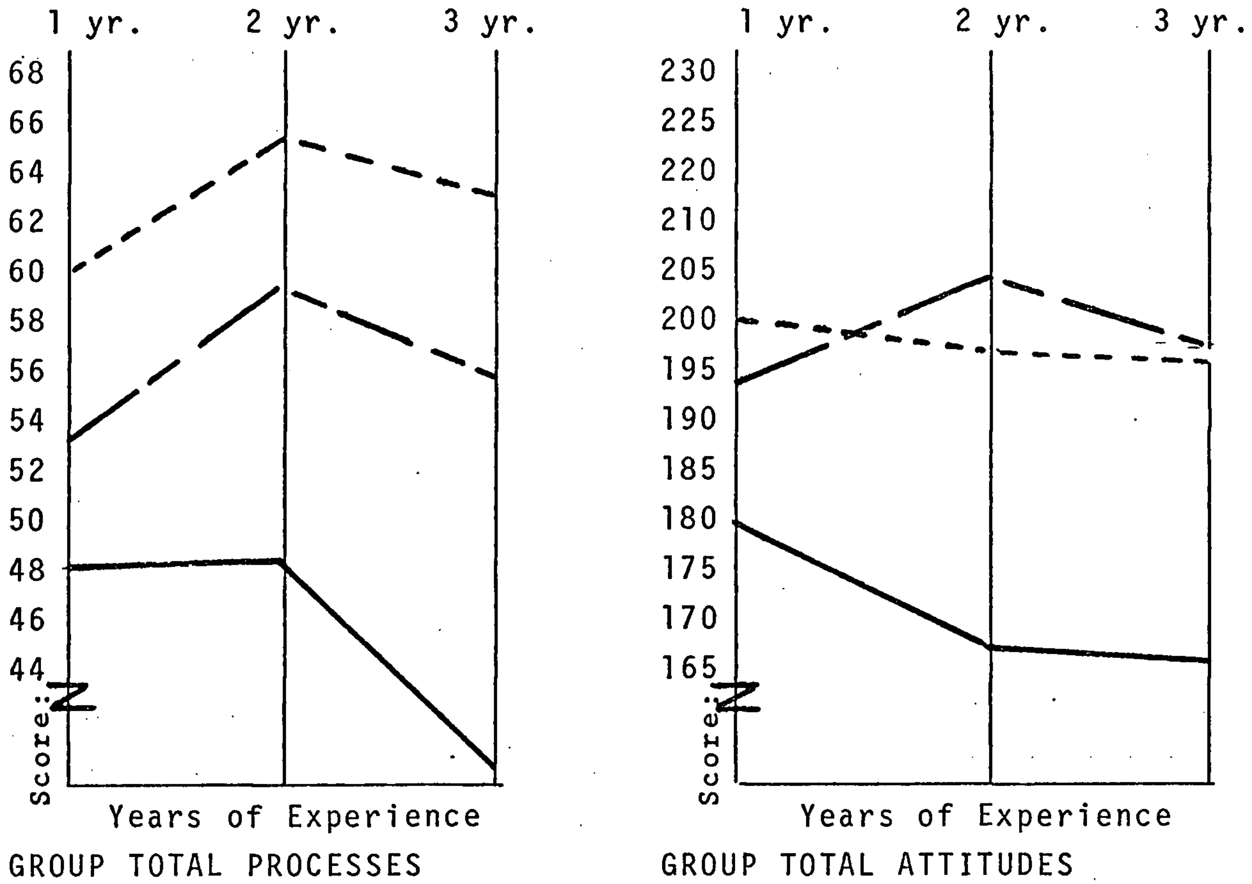


Fig. VI: Score Trends for Total Attitudes and Total Processes Based Upon Cell Means from Analyses of Variance (BMDX 64) -- Total Test Scores

Key:

———————— Global (Score 0--5 C.E.F.T.)

—— – —— Middle (16-20)

---------- Analytical (27-25)

Fig. VI(Cont'd)

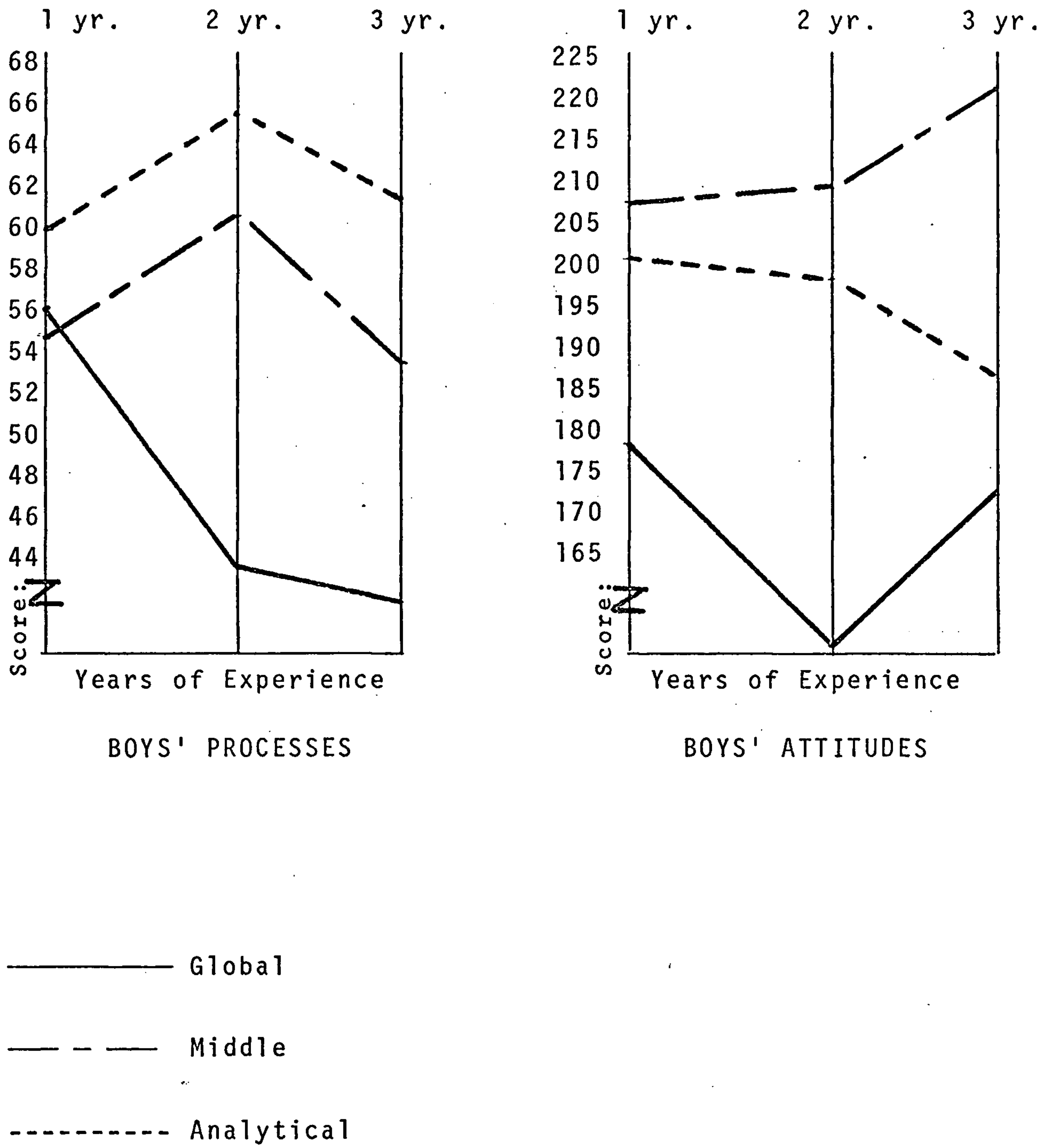
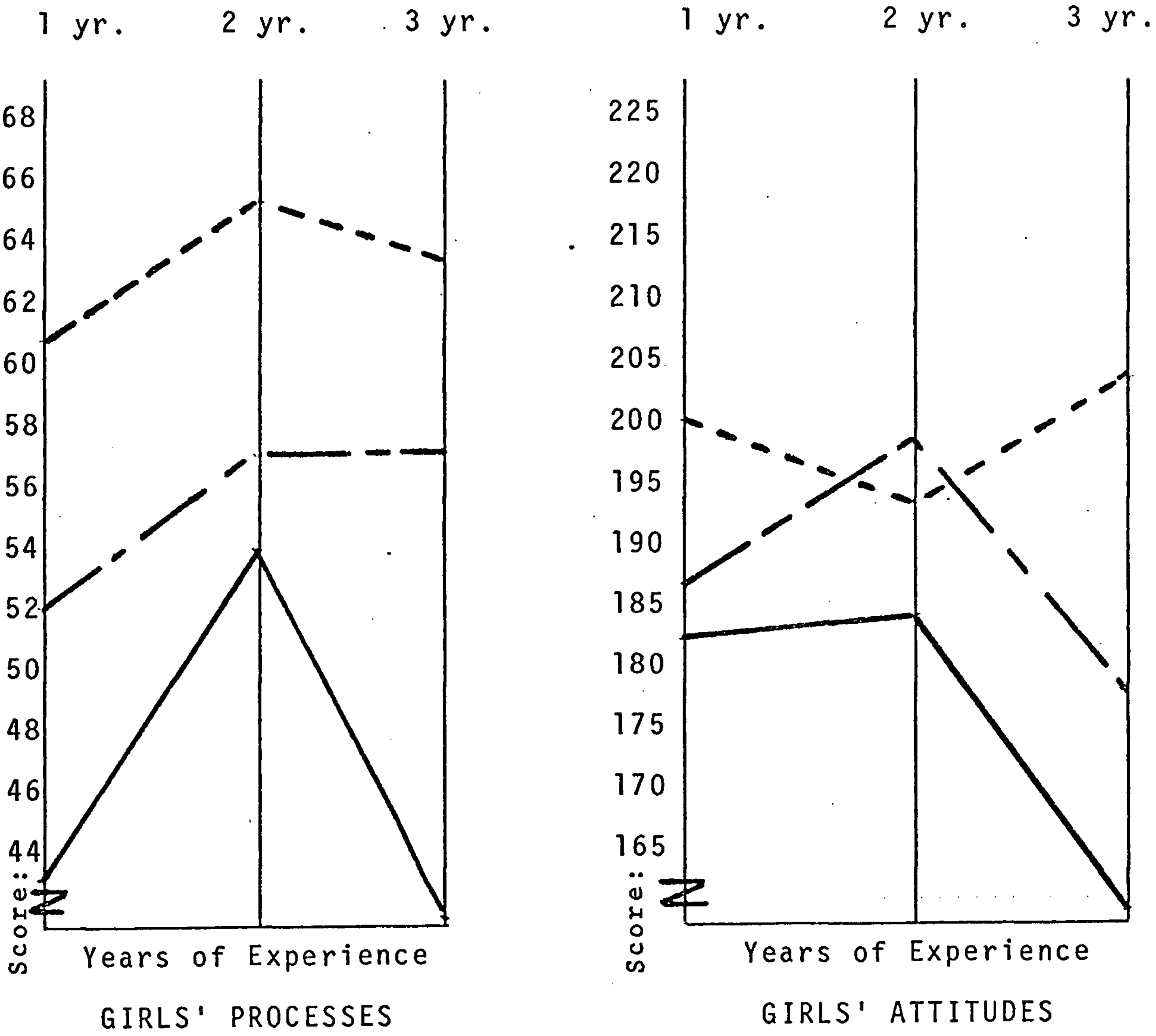

1 yr.
2 yr.
3 yr.
68
66
64
62
60
58
56
54
52
50
48
46
44
Score:
Years of Experience
BOYS' PROCESSES
1 yr.
2 yr.
3 yr.
225
220
215
210
205
200
195
190
185
180
175
170
165
Score:
Years of Experience
BOYS' ATTITUDES
Global
Middle
Analytical

Fig. VI (Cont'd)



———————— Global

— — — Middle

---------- Analytical

CHAPTER V

CONCLUSIONS AND SUMMARY

5.1 This Study Developed from a Need which Arose in the Classroom

The reader should consider this exploratory study within its proper context. This investigation grew out of the author's classroom teaching experience in which it was observed that certain children appeared to experience much difficulty while operating within the rather unstructured learning experiences of the Elementary Science Study. The theoretical framework of Witkin's *Differential Psychology* (1967) appeared to be of some assistance in explaining why the highly praised and relatively novel teaching materials and methodology of the Elementary Science Study did not appear to be successful with these children referred to above. It was the author's wish to initiate an investigation to determine if the apparently pervasive individual trait of cognitive style would be helpful in explaining differences in achievement in this rather unstructured curriculum. Achievement was measured in terms of attitudinal and heuristic science competencies. Further, it was intended that by analyzing cross-sectional data, it would be possible to obtain some insight regarding the effect of cognitive style over time -- as children had more and more experience with the Elementary Science Study materials and methodology.

5.2 Limitations of the Study

Because the analysis of the effect of years of E.S.S. experience was based upon cross-sectional data, interpretations about the effects of exposure to the E.S.S. program could only be described as a form of statistical speculation. Ideally a longitudinal study should have been done, but as this particular study was an exploratory investigation, it was reasoned that should Witkin's construct of cognitive style bear significant relationship with performance on the type of elementary science competencies appropriate to the E.S.S. curriculum, then the investment of time and labour on a longitudinal study would be warranted. The findings of this thesis appear to support the desirability for such a longitudinal study.

5.3 Conclusions and Recommendations

a) The Effect of Years of E.S.S. Instruction:

There was no statistical evidence to state that performance on the criterion measures improved as children had more and more exposure to the E.S.S. programme. This finding should not be viewed as a general indictment of the E.S.S. programme, but rather as an indication of the probable weakness of the cross-sectional research design employed by the author. There were likely too many intervening variables unaccounted for, to come to any firm conclusions about the effect of years of E.S.S. instruction. A longitudinal study would eliminate this difficulty.

b) The Interaction of Cognitive Style and Years of E.S.S. Instruction:

Similarly interpretations of interactions between experience on the programme and cognitive style are extremely difficult, again because of the assumptions made by the design. Nevertheless, it seems apparent that the E.S.S. curriculum should not be viewed as some educational panacea. Graphs of score trends appear to indicate that the more global children may actually regress on competency measures as these children have more and more experience with E.S.S. curriculum. A proper longitudinal study of intermediate-aged students may affirm this speculative conclusion.

The limitations imposed by the design on the conclusions regarding the effect of years of experience and interactions, do not apply for the main effect of cognitive style, because the parameters of cognitive style were clearly defined in terms of performance on the *Children's Embedded Figures Test*.

c) The Effect of Cognitive Style on Performance on the Test of Science Processes:

It was found that children who could be categorized as perceptually global, achieved significantly lower scores on both cognitive and affective measures of elementary science competencies. With regards to the cognitive objectives which were measured by the *Test of Science Processes*, it was found that the global group did significantly less well on the set of eight science processes. Further, it was found that on the measures of Observation, Classification, Quantification, Measuring and Inferring -- these tests were each in themselves sufficient to conclude that the global group achieved statistically lower scores than the analytical group on the set of science processes.

d) The Effect of Cognitive Style on Performance on the Attitude Scales:

With regards to the affective objectives -- the attitudes concerning "messing about in science" -- there was a statistical basis to conclude that the global children achieved significantly lower scores than the analytical children on the set of attitudes scales. It was found that differences on the Pursue Scale (D2) and the Individual Investigation Scale (D4) were each sufficient in themselves to conclude that the global group achieved statistically lower scores than the analytical group on the set of attitude measures. Although there was some evidence that global children did less well on measures of the enjoyment attitude (D1) and on the attitude of imposing structure on play (D3), the evidence was perhaps confounded by a number of factors. For instance, cultural ethics regarding inculcated evaluations of the concepts of "work" (structure) and the concept of "fun" may have been involved. For example, sex differences were found with regards to D1 and D3 which may have indicated the effect of role enculturation, i.e. values which the culture inculcated in girls, such as being non-mechanical and "feminine."

e) General Conclusions and Recommendations.

Generally it should be viewed as an important finding that perceptionally global children appear to be less well equipped attitudinally and heuristically to operate within the rather unstructured methodologies of the Elementary Science Study (and probably other similar "discovery oriented" curricula as well). This finding is significant both from a theoretical and from a practical viewpoint. Theoretically, it enhances the credibility of differential psychology to educators and suggests its broader application for research. In terms of classroom practice, the author suggests the following recommendations:

e-1 The Modification of E.S.S. Methodology:

The teaching methodology defined by Hawkins (1965) was composed of three phases through which the learning environment was to develop.[1] It is the first of these phases which requires modification. In this first stage, entitled the "O" phase, Hawkins defined a learning environment which he referred to as "glorious messing about" and "kindergarten revisited." During this phase, students of elementary school science were to be allowed to engage in a rather lengthy period of "free and unguided exploration"--this period sometimes was to take as long as two weeks. In his much cited article Hawkins stressed the need for a

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[1]The "**O**", "**Δ**", and "**□**" phases of E.S.S. methodology are fully described in Appendix B.

re-emphasis upon this type of learning which typifies the style of learning exhibited by children before they come to school. Indeed, Hawkins even suggested the broader application of the "O" phase to the college level. In his zeal to de-emphasize the "□" phase, (abstract and theoretical teaching strategies such as lecturing), Hawkins committed an error of omission. Teachers have long been aware that some children appear to have a poverty of resources at their disposal. These pupils appear to be unable to engage in sustained play with materials. These children are not as capable of profitably utilizing extensive periods of unguided exploration in science classes. *Differential psychology* provides a theoretical framework which should be of great assistance in helping educators to provide for the type of individual differences referred to above.

From the research of Witkin and his followers, it would appear that the degree of cognitive style (global versus analytical funtioning) is generally a pervasive trait after the age of eight years. It would seem to the author, therefore, that especially in the upper elementary school grades, the individual cognitive style of children is an important factor which educators should attempt to accommodate when designing and implementing curriculum. It would be naive to consider that the mere application of any one curriculum would suddenly alter the cognitive style of older children (to drastically enhance the differentiation process), because the child's particular mode of dealing with the world has become well reinforced and entrenched by this time. Educators therefore must learn to provide for the individual differences in cognitive style. In the E.S.S. scheme for example, global children have a distinct disadvantage when compared to the more analytical children -- while learning within a "fend for yourself" learning environment. The teacher should identify the children at the extreme ends of the differentiation continuum (utilizing such tests as C.E.F.T.) and he should modify the "O" phase for these children. Extremely global children require conscientious, systematic guidance and supportive assistance -- while analytical children require very little interference by the teacher during this "O" phase.

In the primary grades a more detailed methodology should be developed and tested; at this level it may be possible to enhance the differentiation process and by so doing, to actually alter the extremely global child's mode of dealing with the world. This methodology for primary school instruction could be based upon the existing data and theory regarding the child-rearing practices of the parents of more analytical children. The actual development of special teaching strategies which would enhance the differentiation process for young children is beyond the scope of this study. In short, *differential psychology* presents a theoretical and empirical basis from which to develop differentiated teaching methodologies.

e-2 The Modification of the Way Curriculum is Used:

Currently the "unit" approach to curriculum is a popular method of applying the materials of the many elementary science projects. For example, teachers may be planning to utilize *Batteries and Bulbs* (E.S.S.) followed by *Pendulums* (E.S.S.) -- or perhaps another unit from an entirely different curriculum project with a very different philosophy. Rather than approaching the study of topics or objects through the selection of "a unit" (unilaterally administered to the entire class), the author suggests the following modification in the way that curriculum materials are currently used. The study of topics or objects could be approached in such a way as to account for the styles of learning which are more appropriate to the cognitive styles of particular children. Several *avenues or paths of learning* should be available on any particular science topic. These paths would differ in *the degree of structure and support* which they afford the teachers and pupils who wish to investigate a topic.

The children and the teachers could decide which path is most suitable. The author does not necessarily suggest the design of entirely new curricula based upon the concept of differentiated routes to learning (although such a curriculum design may be feasible), he suggests however, that it may be presently possible to achieve the desired end by making much better use of curriculum materials which have already been developed. These many curriculum projects themselves have built-in features which reflect particular philosophies and methodologies. Consequently, the entire spectrum of structured versus relatively unstructured elementary science experiences is already available under the covers of these pre-existing curriculum projects. The author recommends that science educators extract the different approaches to given topics from these separate entities, and integrate the various approaches to the topics -- thus providing *alternate routes to learning* a topic. For example, A.A.A.S. lessons regarding seed germination could be compiled and offered as a more structured path to the topic than the more "free-wheeling" E.S.S. units such as *Starting from Seeds*. Students could then be afforded a choice as to which path they wished to follow -- structured versus relatively unstructured.

5.4 Implications for Further Research

As suggested at the beginning of this chapter, there is sufficient evidence about the applicability of the psychological construct of cognitive style to justify development of a longitudinal study (similar in format to this one), in order to determine the interaction of cognitive style and years of E.S.S. experience on performance on elementary science competency measures. It is suggested that this study begin at the lower intermediate grade levels and should continue to the end of elementary schooling.

In the primary grades, particularly in kindergarten and grade one, it would be an exciting study to determine the stability of cognitive-style when the teacher conscientiously adopts the type of supportive treatment which Witkin and his associates identified as the child-rearing style employed by parents of field-independent (more analytical) children. The author hypothesizes that such early school experiences would enhance the differentiation process for exteremely global children.[1] What is intended is that the environment of these children be manipulated conscientiously and intensively for several

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[1]Cognitive style has been found to be stable and pervasive (relative to the group) in stable environments.

years in order to determine what changes could be effected upon cognitive style -- a construct which has been considered by researchers to be pervasive and relatively stable compared to the group norms. Cognitive-style would become the dependent variable of such a study. This investigation may indicate that it is truly possible to bring about a change in cognitive-style! It may be possible to foster the process of differentiation

> . . . *in such a way that the child's own rich world of exploration becomes more disciplined, more manageable, and more satisfying."* (E.S.S., 1965, p. 4).

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APPENDIX A

THE SELECTION OF PERFORMANCE CRITERIA

It is an enormous task to attempt to learn something about the nature of children who experience difficulty working within the framework of the Elementary Science Study. Of the many curricular projects which have been adopted by public schools, the author selected the Elementary Science Study, because it had been consistently adopted by many school districts, because it appeared to be one of the most popular programs, and because it was the one program with which the author had had a great deal of personal classroom experience.

The selection of the Elementary Science Study as the treatment experience for the subjects in this study, however, presented some difficult problems which had to be overcome before the study of the general problem could continue. Determining the important measurable objectives was one such problem and the development of specific test instruments to measure these objectives was another.

In the past, teachers of elementary science have evaluated their students by emphasizing in their tests such things as factual recall, recognition and other low level cognitive processes. With the advent of many new curriculum projects, a new emphasis has been placed on such objectives as the acquisition of scientific and humanistic attitudes and the fostering of creative talent. Consequently, evaluation in the traditional sense has become insufficient and in some situations, inappropriate. For example, teachers are now instructed to determine ". . . how each child is developing his own skills in scientific investigation" (Elementary Science, 1969, p. 26). Suggestions for carrying out these forms of evaluation include anecdotal reports, checklists, interviews, and paper and pencil tests.

This trend away from simply attempting to measure how well children commit to memory facts from textbooks or facts from teacher presentations, is an obviously necessary one. In any case, since curricular objectives have been modified drastically, so must the evaluation techniques be redesigned to measure these new objectives. The literature in science education reveals that many articles have dealt with the problem of developing suitable evaluation techniques. For example, the curriculum which has been developed by the American Association for the Advancement of Science, possesses a specially developed evaluation model which was tailored to meet the specific needs of this program (A.A.A.S., 1970). On the other hand, one of the most prolific and one of the most popular curriculum projects, the Elementary Science Study group, has stated that present evaluation techniques have continued to be so inadequate that such measurements might even be a dangerous and inhibiting influence on curriculum innovations. Consequently, this group has done relatively little in developing evaluation instruments and methods (Quarton, 1966, p. 7; Lockhardt, 1967, p. 240). Nevertheless, attempts must be made to develop more adequate evaluative techniques because school officials are required to justify innovations. This trend toward public accountability appears to be growing (Elliot, 1970). If appropriate evaluation methodologies are not developed, then inappropriate ones may find themselves in use in the absence of more suitable ones.

The problem of developing evaluative strategies is further complicated because institutions which have developed such excellent materials as the internationally reknowned E.S.S. group, have been reluctant to state their objectives in a complete, clear and orderly fashion. The following statement is the list of objectives that were reported to the International Clearinghouse for Science and Mathematics Curricular Developments (Lockhard, 1967):

> *Behavioral objectives identified: We have identified some. We feel that if the materials are well designed children will be deeply involved and highly motivated to continue with their owrk. We use such criteria as noise level, general order, attention to the work at hand and design of new experiments by the children. We also have as objectives an increase in problem solving skills, an improvement in the ability to predict what will happen under certain experimental conditions with ther materials involved.*
>
> *Research evidence of objectives achieved: Our evidence comes from anecdotal reports from teachers and from close and lengthy observations made by our own staff in classrooms* (Lockhard, 1967, p. 241).

It merits emphasizing, however, that this curriculum group's rather vague mode of dealing with the question of evaluation is epitomized in the introductory statement, "We have identified some." This vagueness made the task of determining the measurable objectives of this curriculum very difficult.

The writer felt that a necessary requisite for solving the problem of determining objectives should involve the following procedures:

1. Gaining experience with the program by teaching children of all grade levels, utilizing the E.S.S. materials, following the suggestions of guide books and employing E.S.S. teaching strategies. This experience should span a number of years.

2. Talking to other teachers and to children about their thoughts about the E.S.S. materials.

3. Studying and analyzing the literature that has been released by the E.S.S. group.

Having undergone these procedures, the writer felt that he had the basis for an understanding of the objectives of the program. His persistent belief was that there were many implicit objectives in addition to those that are listed in the official E.S.S. statement of objectives.[1] For example, after having experience with both E.S.S. material and A.A.A.S. materials, it was rather apparent that the children who were using the E.S.S. materials were also acquiring practice in using the same types of processes of scientific investigation that the A.A.A.S. group listed as primary objectives.[2] In order to confirm these observations about other implicit objectives of the E.S.S. group, the writer then examined the published units and the following E.S.S. materials with the purpose of identifying the implicit objectives of E.S.S. materials:

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[1]This statement of objectives will be further analyzed in Appendix B.

[2]In E.S.S. *Rocks and Charts*, the pupils classify. In *Kitchen Physics*, the pupils graph, use space-time relationships, predict, infer, etc.

1. The entire E.S.S. report submitted to the International Clearinghouse for Science and Mathematics Curricular Development, (1967).

2. The much cited article by David Hawkins, the former director of the Elementary Science Study. This article is entitled, "Messing About in Science." Hawkins (1965) outlined E.S.S. teaching strategies.

3. The general information bulletins which are entitled *Introduction to the Elementary Science Study*.

Key words were underlined in each sentence. Key words were defined as words which told or described what children actually did in science classes. These words and phrases were then listed on cards, the cards were then shuffled and categorized. The final categorization revealed clusterings of key words which were labelled with the following headings:

1. Beliefs concerning the merits of "messing about"
   a. "Messing about" is fun.
   b. "Messing about" will lead the children to pursue and follow up phenomena which are uncovered.
   c. "Messing about" will lead children to impose a structure on their play.
   d. "Messing about" will lead children to investigate on their own.

2. Science processes:
   a. Observing
   b. Classifying
   c. Analyzing
   d. Controlling variables
   e. Predicting
   f. Handling data

g. Experimenting
h. Replicating
i. Posing problems
j. Acquiring practical skills

3. Creative component: free wheeling speculation, creative problem solving, and intuitive, playful exploration.

4. Manipulative and building skills

5. Cognitive development
   a. Specific concept development
   b. Incidential learnings

To avoid this study taking on unmanageable proportions, it was feasible to match only some of these objectives with suitable tests. The writer selected a recent test, *The Test of Science Processes* (Tannenbaum, 1969), because it appeared to provide a reasonable match to the second clustering of objectives mentioned above. It was reasonably easy to match the type of behaviors which are defined in the blueprint for the *Test of Science Processes* with those behaviors that occur in E.S.S. situations.[1] Because

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[1]For example, the blue-print defines five behaviors to be tested under the science process, *Observing*. The following illustrates that it is reasonably easy to match these behaviors described in the blueprint of *The Test of Science Processes* with E.S.S. activities,

Behavior	Questions	EES Units
1. Demonstrate an operational knowledge of the physical properties of objects.	14,19 14,19	Attribute Games Rocks and Charts Kitchen Physics
2. Identify and describe objects which interact in a system	13,18	Bones, Bulbs & Batteries, Gasses and Airs

(Tannenbaum, 1969, Appendix C)

the E.S.S. group stressed the need for children to acquire the attitudes described above (cluster 1), the author also chose to measure those objectives as well, and as a consequence four Likert-type attitude scales were developed. The techniques involved in developing these scales are fully described in Appendix B.

APPENDIX B

THE DEVELOPMENT OF FOUR ATTITUDE SCALES TO MEASURE CHILDREN'S ATTITUDES TOWARDS THE AFFECTIVE OBJECTIVES OF THE ELEMENTARY SCIENCE STUDY

E.S.S. Literature Corroborates the Importance of the Affective Objectives Established by the Procedures Listed in Appendix A

In order to measure the attitudinal objectives discussed in Appendix A, it was necessary for the author to construct four attitude scales. In this appendix, the conclusions of Appendix A will be corroborated by statements from E.S.S. literature. It will be shown that if the aim of the E.S.S. program is to bring about attitude shifts in children, attitude testing is necessary if one is to assess the pupils, the teachers, or the learning environment. Following this argument are definitions of attitude and other relevant terms; reasons for the selection of a Likert-type scale; and the procedures employed in developing the scales. Finally, the scales in their final test form are included along with relevant statistical data about each scale.

Besides the usual objectives which emphasize the necessity for children to acquire the skills or processes of science, the E.S.S. group developed materials and strategies which they hoped would develop certain crucial attitudes in children. One could view these materials and strategies as a series of treatments which are supposed to bring about an attitude shift in students. Throughout the E.S.S. materials there are countless references to the effect that E.S.S. experience would bring about the attitude that science is fun to do. Perhaps the most obvious statement of this objective can be found in former E.S.S. Director David Hawkins' article "Messing About in Science" (1965). Hawkins began his statement about E.S.S. teaching strategies by quoting from Kenneth Graham's poem *The Wind in the Willows*:

> *'Nice? It's the **only** thing,' said the Water Rat solemnly, as he leant forward for his stroke. 'Believe me, my young friend, there is nothing—absolutely **nothing**—half so much worth doing as simply messing about in boats. Simply messing,' he went on dreamily, 'messing—about—in—boats—messing—'*

In this article, Hawkins defined three sequences of teaching strategies which he labels ○ , △ , and □ . In the ○ phase Hawkins demanded that there be a substantial amount of time for fun and play:

> *There is a time, much greater in amount than commonly allowed which should be devoted to free and unguided exploratory work (call it play if you wish; I call it work). Children are given materials and equipment--things--and allowed to construct, test, probe and experiment without superimposed questions or instructions. I call this O phase. 'Messing About' honoring the philosophy of the Water Rat, who absentmindedly ran his boat into the bank, picked himself up, and went on without interrupting the joyous train of thought* (Hawkins, 1965, p. 6).

It is clear that the E.S.S. group wished children to enjoy science. In their summary of units submitted to the International Clearinghouse for Science and Mathematics Curricular Development (1968), there were no fewer than thirty-one references to an enjoyment factor. One can also find statements in E.S.S. literature which emphasize the intuitive, the imaginative, the playful, and to use Bruner's term, "the left-handed" (Morrison and Walcott, 1962, p. 7). There is ample evidence that the E.S.S. group endeavored to produce materials and teaching strategies which would develop a positive attitude in children toward the belief that "messing about in science is fun." This statement was also the initial belief statement of the first scale.

The second attitude scale was constructed around the belief statement that, "From Messing about in Science, children will be lead to pursue phenomena that are revealed." There are many references in E.S.S. literature in which the importance of this attitude is stressed. It was felt that if the materials were appropriate then this attitude of pursuing phenomena would develop:

> *We feel that if materials are well designed, children will be deeply involved and highly motivated to continue with their work.* (Lockhard, 1967, p 241).

In order for the child to make sense out of the phenomena revealed through "messing about" it is necessary that the quality of the play change and become more rigorous and more structured. Hawkins refers to this process in the learning sequences which he labels △ and □ . In these phases of "messing about" the teacher or a film loop may provide a situation in which an anomaly is made more recognizable. In order to make the anomaly behave, the child must impose a structure on his play. It is hoped that the child may take experiences with things and be able to ". . . analyze them, abstract from them, and perhaps even reach a generality which he can test in other situation" (E.S.S., 1965, p. 9). Clearly the E.S.S. group also wished to foster the attitude that "through messing about Children will impose a structure on their play:"

> . . . *we have found basic agreement that a major aim of our project must be to* *encourage children to examine, analyze and understand the world around them and to stimulate their desire to continue to do so* (E.S.S., 1965, p. 7).

This attitude of "imposing structure on play" became the basis for the third attitude scale.

Finally, there was considerable evidence in the literary discourse that the E.S.S. group wished to foster the attitude that "through 'messing about' children would investigate independently." For example, even in the brief statement of objectives, there was a reference to the ". . . design of new experiments by the children" (Lockhard, 1967, p. 241). It is hoped that children will be able to and inclined to investigate phenomena independently, without the teacher. This attitude that "messing about" will lead the children to be positive toward investigation of phenomena on their own, became the core of the fourth and final attitude scale developed by the author.

Definitions of Attitude Indicated that Summated Ratings Provided a Workable Model for Attitude Measurement

Because this curriculum project aimed to utilize elementary school experience as a vehicle which would help the child become a scientifically curious person (E.S.S., 1965, p. 7), it can be concluded that this aim is primarily an attitudinal one. The author must agree with the emphasis that this curricular project places upon affective objectives. It matters little if teachers are capable of producing students proficient at scientific competencies, if the children do no carry these competencies out of the contrived environment of the classroom into the real world.

The term "attitude" has been defined in many ways. In the psychological literature there are many attempts at categorical definitions while many writers prefer to give very limited definitions to the term. These definitions vary with convention and the author's purpose. For example, Krech, Crutchfield and Ballachey (1962, p. 152) define attitude as

> . . . *an enduring organization of motivational, emotional, perceptual, and cognitive processes with respect to some aspect of the individual's world.*

Newcomb, Turner, and Converse (1965), however, define attitude as "a state of readiness for motive arousal." One attribute of the construct of attitude seems to be important to this study in particular. The 'action tendency' component of attitude seems to be especially important when considering the affective objectives of the Elementary Science Study:

> *Attitudes are commonly distinguished from cognitions, abilities, capacities, or intelligence not only by the presence of an affective component but also by the conventional assumption that the mere presence of the relevant object is enough to trigger the prepared response which does not require additional motivation. A person who 'knows how' to add will not necessarily do so in the presence of numbers, but the person who likes to add may be expected to do so when given the opportunity* (Scott, 1968, p. 207).

Similarly in elementary school science, a person who is able to use the processes involved in scientific investigation won't necessarily investigate in the presence of suitable materials, but a person who also likes to employ these processes may be expected to do so when given the opportunity. The following quotation from E.S.S. indicates that it is this "tendency for action" which is an essential part of their objectives:

> . . . *we have found basic agreement that a major aim of our project must be to encourage children to examine, analyze and understand the world around them and to stimulate their desire to continue to do so*. . . . [emphasis added] (E.S.S., 1965, p. 7).

". . . their desire to continue to do so" involves the notion of action tendency or motive arousal discussed above.

Other elementary science curriculum projects have not only emphasized the importance of asserting affective objectives, but have attempted to develop instruments which would measure attitudes. It is of interest to note that even one of the most structured curricula in elementary science, the programme developed by the A.A.A.S. (Science: A Process Approach) has recognized the need to foster the development of positive attitudes and has also initiated the research into the semantic differential technique as it applies to this particular curricular model.

In order to evaluate the student's acquisition of the attitudes that have been shown to be objectives of the Elementary Science Study, the author decided to utilize the Likert method of summated ratings. Because the first part of each of the four belief statements involved what Hawkins called "Messing About in Science," summated ratings seemed to be the most suitable technique to convey the meaning of the term "messing about" as Hawkins used it. It was felt that the very diversity of elementary science activities could be used to convey the notion of "messing about," and that these diverse situations would assist in providing many of the attributes of the construct of attitude that are referred to by Scott (1968, pp. 204-273).

Scott listed eleven properties of attitudes: direction, magnitude, intensity, ambivalence, salience, affective salience, cognitive complexity, overtness, embeddedness, flexibility, and consciousness. Scott emphasized that many properties of attitude have not been considered by scale makers:

> *The critical point to be noted is that, if one is to 'measure attitudes' as they are conceptualized in the literature, one needs to find ways of operationalizing, and converting to numbers such properties as these. In actual practice, most of them have not been operationalized satisfactorily, let alone scaled. By far the greatest attention has been devoted to the measurement of magnitude (or intensity) so the ensuing description of measurement procedures will focus exclusively on this property. Comparable measuring procedures could, in principle, be applied to most of the other properties as well* [direction, magnitude, intensity, ambivalence, salience, affective salience, cognitive complexity, overtness, embeddedness, flexibility, consciousness] (Scott, 1968, p. 208).

Realizing that present day attitude scale techniques have many short-comings, the author felt that the Likert technique was probably more appropriate for this study than any of the other methods. Edwards (1959, p. 168) cited evidence that the correlation between Likert Scales and Thurstone Equal Appearing Interval Scales, indicated that there is nearly a perfect relationship between the scores of the two different attitude scales. Edwards concluded that in his particular study:

> *. . . we might predict that the relative ordering of the subjects on either an equal-appearing interval scale or a summated rating scale would be, for all practical purposes, essentially the same.* (Edwards, 1957, p. 168)

The Likert scaling technique was selected by the author after consideration of alternatives. The Likert scaling technique appeared to hold promise of guaranteeing a certain amount of salience. By including belief statements about dozens of actual elementary science activities (what the children really did in science classes) in the assertions about the attitude objects, the author felt that the scales would be pertinent and meaningful measures. By obtaining these statements by means of tapping the belief pool of elementary science students, there seemed also to be a guarantee that the test would provide measures of real attitudes towards real objects in the children's psychological world. Further, the Likert technique provided a situation in which assertions about the attitude object can be placed within the meaningful context of actual classroom behaviors. The author also felt that the Likert technique would best make use of his experience as a practicing elementary school teacher as the task of developing salient items in these scales demands the tacit knowledge of a practicing teacher.

Fishbein (1967, p. 395) cited Rosenberg's study in which it was found that

> *. . . estimates of attitudes based on a consideration of an individual's salient beliefs (i.e., those elicited by the subject) were considerably more accurate than estimates based on a consideration of beliefs selected on an a priori basis.*

Within each scale one can find items that involve many of the properties of attitudes mentioned by Scott. Many of the items reveal the diverse nature of the attitude domain that is being measured by each scale. Some of the items even resemble Bogardus' (1925) social distance measures.[1] It has been this writer's persistent belief that when items are developed from the background of practical experience of the test maker and actual experiences of the testing population, the Likert technique provides a workable model for developing attitude measures. Further, the summated rating technique, when utilized as it has been in this study, does not appear to be inconsistent with more recent theories:

> *In addition, it should be noted that according to the theory,* [Fishbein's] *every time an individual learns a new belief that associates the attitude object with some positively evaluated concept, his attitude will change in a positive direction. Similarly, if the new belief associates the*

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[1]For example, item 17 reads "People who like doing science experiments are creeps."

> *attitude object with a negatively evaluated concept, his attitude change would be in a negative direction. That is, attitude change, as well as attitude per se, is viewed as a function of the* total *amount of affect associated with an individual's beliefs about the attitude object. In contrast to this, most theories based on a notion of "consistency" would predict that attitudes and attitude change are functions of the mean amount of affect associated with an individual's beliefs.* (Fishbein, 1967, p. 398).

Summated ratings, as they have been developed for this study, attempted to measure attitude "as a function of the total amount of affect. . . ."

Procedures Employed in Developing the Likert Scales

The construction of the four Likert-type scales initially followed the procedures described by Edwards (1957), with other additional procedures employed as well. More elaborate methods were involved in constructing the final form of the test. This section will indicate how the preliminary version of the scale was drawn from the belief pool of the population to be tested; how this selection was validated by expert judges; and how item analysis of the preliminary scale was carried out. Following this presentation there will be a description of the procedures involved in producing the final scale, and the procedures employed in developing the audio-visual form of the test.

Tapping the Belief Pool of the Population

Two classes of grade seven children who, in the opinion of the Supervisor of Instruction, had been following correctly the program developed by the Elementary Science Study -- were selected to provide information about the belief pool of the population. A booklet was provided to each of the sixty pupils; on each page the students were asked to respond to one of the following statements:

Page 1. What I feel about doing science in school.

Page 2. "Messing about" in science is fun and interesting [Scale I].

Page 3. When "messing about" in science, I follow-up things that I notice [Scale II].

Page 4. Do you measure things that you notice? [Scale III]

Page 5. By being allowed to "mess about" with things in science, I enjoy being able to figure things for myself [Scale IV].

Page 6. I wish I had more help from my teacher when I am doing science [Scale IV].

Students were told to react freely to these statements. They were informed that they need not comment unless they felt like doing so. Students were also advised that their comments were confidential and had nothing to do with report cards and that their comments were to serve someone at U.B.C. who wanted to know how students felt about doing science in school. Students inquired whether "mess about" meant "horseplay--fooling around." The pupils were informed that "messing about" meant "playing and using equipment and stuff, like you have been doing for several years in science classes." The children's responses provided a large pool of statements about the attitude objects of the four scales.

Developing the Initial Set of Items

Items were selected from the belief pool and some of these items were modified so that there would be the same number of positive assertions about the attitude object as there were negative assertions. Three outstanding elementary science teachers were called upon to validate whether each statement was indeed an assertion about the attitude object of each particular scale. The judges were provided with a list of the items and were also given the four key assertions about the attitude objects. Judges were asked to judge whether each item was a positive way of saying the assertion about the attitude object, a negative way of saying it, or whether the item was not a way of saying the assertion. Judges made a positive mark beside each item, a negative mark beside the item or drew lines through irrelevant items. Judges also made suggestions which improved some items. Items for which there was complete agreement as a positive or a negative assertion were kept intact. Items for which there was only partial agreement were rewritten and resubmitted to the judges. Items that were crossed-out were rejected. The items that survived with the complete agreement of the judges formed the preliminary version of the four attitude scales. Scale one consisted of 40 items, scale two 30 items, scale three 30 items and scale four 43 items. In order to reduce the reading ability factor in interpreting the results of the administration of these scales, a preliminary taped version of this scale was also produced.

Selecting the Final Set of Items

The four scales were then administered to thirty-eight grade seven pupils at Dr. H. N. McCorkindale Elementary School. These pupils had also had several years of E.S.S. experience. Students were informed that their responses would be confidential and would not be shown to anyone at their school. Students responded anonymously on answer sheets designed to be mechanically scored.

Students were told to show how they "really and honestly felt" about statements which described different situations in elementary school science. They were instructed to listen to the taped statement then to read it if they wished and then to respond to a five point agree or disagree scale. Items were scored 4, 3, 2, 1, and 0. The scoring of negative items was reversed. Scores for each individual were summated. Following the method suggested by Edwards (1957, pp. 152-159), item analysis was then done. The top 33 per cent and the bottom 33 per cent of the subjects with the highest and the lowest scores were assumed to provide criterion groups in terms of which each individual statement could be evaluated. The following "t" ratio was used to evaluate each statement:

$$t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{S_H^2}{N_H} + \frac{S_L^2}{N_L}}}$$

where X_H = the mean score on a given statement for the top group

X_L = the mean score on the same statement for the bottom group

S_H^2 = the variance of the distribution of responses of the top group to the statement

S_L^2 = the variance of the distribution of responses of the bottom group on the statement

N_H = the number of subjects in the high group

N_L = the number of subjects in the bottom group

Utilizing U.B.C.'s Triangular Regression Package (TRIP), "t" values for each item were calculated. To be significant at the alpha level of .001, "t"'s needed to exceed 3.045; similarly "t"'s needed to exceed 2.750 for the .01 level and 2.041 for the .05 level of significance.[1] With the exception of a few items which approached significance, items which failed to exceed the .05 level of significance were rejected. The two items which approached significance were rewritten and included in the final scale. Fifty-two of the items were significant at the .001 level, 9 at the .01 level, and eighteen at the .05 level. Utilizing a table of random numbers the items that survived were then randomized in order to reduce the possibility of one

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[1]These critical values of t were determined at 38 degrees of freedom (one-tail).

type of response set manifesting itself in the responses of the subjects. The final forms of the four scales each contained twenty items half of which were positive and half of which were negative.

The final form of the scales was composed of four separate test booklets. To accompany the visual form of the scale a final tape recording of each statement was also made. Mr. Mark Hartford a trained broadcaster from the audio-visual department in the Faculty of Education, U.B.C., read each item into the recorder in a clear and objective manner. Just enough time was allowed so that a person could listen to the statement, read it, and respond on the mechanically marked answer sheet--the extent to which he agreed or disagreed. It was felt that this format would assist in making the scales a more pleasurable task to face and also that the taped version would minimize reading difficulties and reading errors. The instructions to the subjects were also given on the tape which helped to standardize the testing situation.

The final scales were administered in two sittings to each of seven grade seven classes who have had experience with Elementary Science Study materials over a lengthy period of time. The responses of 184 subjects were then used for further analysis. The response sheets were marked by the U.B.C. Computer Center's IBM 1232 Optical Scanner and responses were punched on cards. The analysis was done on U.B.C.'s IBM 360 facilities. The following special programmes were written by James Gaskill of the Mathematics Education Department at U.B.C.:

> Program One adjusts the scores from the cards produced by the optical scanner and transforms them to the correct mode and to the proper values of 0, 1, 2, 3, and 4.
>
> Program Two reverses the negative items, sums each of the four scales and sums an overall total score as well.[1]

Both scales are listed at the end of this appendix.

Before the administration of the scales, students were told that their reactions to the statements were to be kept confidential. It was emphasized that the researcher wanted to find out how students really felt about the attitude statements. Students were asked to respond honestly rather than in a manner which considered how someone

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[1]These programs are listed at the end of this appendix.

else like their teacher, would expect them to respond. These instructions were repeated in the tape recording.[1]

Statistical Analysis of the Attitude Tests

Analysis was carried out utilizing the principal components factor analysis program which is entitled U.B.C. FACTO. The preliminary factor analysis revealed that there were thirty factors with Eigen values greater than one, and these thirty factors accounted for 70 per cent of the variance.[2] Because the first five factors accounted for much of this variance, principal components factor analysis with varimax rotation was carried out while restricting the number of factors to five. When the Eigen values of the factors were plotted the slope was negligible beyond five factors. The four attitude total scores and the grand total were also included as variables in this analysis in order to determine the factoral composition of the scales. It was hypothesized that the four scales would each be composed of mainly one unique factor. To some degree this hypothesis was upheld.

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[1]Many of the students remarked that they found the taped instructions and scale items very helpful.

[2]Nunnally (1967, p. 256) suggested that one can expect a large number of "factors" with 184 subjects and 80 items.

An attempt was made to identify and label these factors by determining the common logical attributes of those items which possessed common factor loadings. Consequently, Factor A has been labelled "the fun factor"; Factor B "the insecurity factor"; Factor C "the imposing structure factor"; Factor D "the independence factor"; Factor E "the ego identification with science factor." Factor E appears to be the least important factor in all four of these scales. These factor loadings are summarized on the following page. It can be seen that Scale I is loaded primarily on "the fun factor." Scale II was judged to be logically unique, however it appears to be a composite scale factorally. Scale II has been constructed to be logically different from the other three scales. It can be argued that the three major factors in the scale combine to produce a unique scale. Just as the color green can be shown to be composed of two primary colors, the color green, is still green -- neither yellow nor blue, but a unique color -- green! So too, Scale II is composed of certain combinations of Factors A, C, and D. Nevertheless the scale still stands as a logically unique entity.[1] Scale II has demonstrated that it is a

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[1]Perhaps Scale II could be referred to as a secondary scale factorally, while the other scales could best be described primary scales, factorally.

Table B1

Factor Loadings on the Four Attitude Scales

Scale	A	B	C	D	E
I	.82106	-.33248	-.22851	.10787	.19605
II	.69923	.19121	-.36221	.36948	.20400
III	.21994	-.08511	-.89052	.30252	.16000
IV	.24947	-.59813	.26475	.62628	.23662
Total	.57830	-.35985	-.53364	.43256	.23850

sensitive instrument that discriminates differently from the other scales. Furthermore, Scale II has an extremely high internal consistency.[1] The differences between Scale II and the other scales are subtle, but then too -- so is the attitude domain being tested.

Scale III is factorally unique, and it is loaded primarily on Factor C. the appropriate factor. Scale IV is extremely interesting, factorally: as this scale appears to be composed of two opposing factors. The first component is Factor D (independence) which is positively correlated with this scale; the second factor is Factor B (insecurity) which is negatively correlated with this scale. In general, Scales I, II, and IV have been shown to be factorally unique. This finding enhances the validity of the scales.

Item analysis was done by computing the Product Moment Correlation Coefficient between the scores of persons on each item versus the scores of persons on each appropriate total score. These correlations can be found in the left hand margin, beside each item in the scales which follow below. Although several items in each scale do not correlate highly with the total score, most items appear to correlate quite well. The internal reliability

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[1]The Cronbach Alpha Coefficient for Scale II is .8239.

of each scale confirms the conclusion that it would not be worthwhile discarding these few items for the purposes of this study. Further refinements could be made at a later date however.

The internal reliability coefficient selected to provide an index of homogeneity was Cronbach's Coefficient, Alpha (Cronbach, 1957, p. 161). The author computed these coefficients on a calculating machine, utilizing the standard deviations of individual items and total scale which was produced as output by U.B.C. FACTO. These standard deviations were squared and the values were substituted into the following formula:

$$\alpha = \frac{K}{K-1}\left[\frac{\sigma_T^2 - \sum^{K} \sigma_I^2}{\sigma_T^2}\right]$$

Where K = the number of items in a scale
I = the item
T = the total or subscale total

The following table summarizes the findings; the table indicates that the scales appear to be highly reliable instruments:

Table B2

Alpha Coefficients, Means and Standard Deviations of the Four Scales

		COEFFICIENT ALPHA				
Scale	K	$\Sigma\ \sigma_I^2$	σ_T^2	α	Mean	S. D.
I	20	35.15452	130.36433	.7687	54.26	11.42
II	20	38.65241	177.95560	.8239	50.22	13.35
III	20	42.34158	185.03752	.8117	43.81	13.58
IV	20	40.41436	183.41962	.8207	45.12	13.54
TOTAL	80	156.56287	1881.10870	.9284	193.4	43.37

Finally, the four scales were correlated with each other, first for the total group and then for boys and then for girls. The resulting correlation matrices reveal that the four domains are more interconnected for the boys and more discrete entities for the girls. Computing the significance of the differences between pairs of correlations in the first figure below indicates that five of the six pairs of intercorrelations for boys and for girls are significantly different. This finding would also lend support to the validity of these attitude instruments. It is the writer's hope that these scales will be useful both to researchers and to practicing classroom teachers.

Below are the intercorrelations among scales. This figure is followed by the actual test form. The item analysis and factor analysis of items preceeds the special computer programs referred to above.

Table B3

Intercorrelations of The Attitude Domains by Sex

BOYS (92)	GIRLS (88) I	II	III	IV	Total Att. Intercor-relation
I	1. / 1.	.6759	.3812 A_1*	.5249 C_1*	.8005
II	.7445	1. / 1.	.5085 B_1*	.4847 D_1**	.8405
III	.5886 A_2*	.6791 B_2*	1. / 1.	.4402 E_1**	.7447
IV	.6391 C_2*	.7122 D_2**	.6698 E_2**	1. / 1.	.7803
Total	.8411	.9030	.8533	.8739	

* sig. different at .05.

**sig. different at .01.

Table B3 (cont'd)

Total Group

	I	II	III	IV
I	1.			
III	.7130	1.		
III	.4960	.6054	1.	
IV	.5886	.6093	.5686	1.
Total Att.	.8227	.8758	.8081	.8331

THE FOUR E.S.S. ATTITUDE SCALES

I	(1-20)	"Messing about in science" is fun. (Fun Scale)
II	(21-40)	"Messing about" leads the child to pursue (follow-up) phenomena that are noticed. (Pursue Scale)
III	(41-60)	"Messing about" leads the child to impose a structure on his play. (Structure Scale)
IV	(61-80)	"Messing about" leads the child to investigate on his own. (Independent Investigation Scale)

Please do not write on the blue pages.

This is not a test for marks. There are no right or wrong answers.

DIRECTIONS: Below are some statement about playing and experimenting in science. We would like to know how you really feel about them. Read each statement carefully, as I read it to you. Then decide whether you (1) agree a lot, (2) agree a little bit, (3) don't know how you feel about it, (4) disagree a little bit, or (5) disagree with it a lot.

EXAMPLE: Grade six and sevens should get paid for coming to school. ________

1. I agree a lot.
2. I agree a little
3. I don't know.
4. I disagree a little bit.
5. I disagree a lot.

100 ☐ ☐ ☐ ☐ ☐
1 2 3 4 5

Now look at the red answer sheet. Look at row 100 on this sheet. Fill in your answer by blackening one of the boxes. If you don't understand, raise your hand.

Now do example 101:

Grade six and sevens should not get paid for coming to school. ________

101 ☐ ☐ ☐ ☐ ☐
1 2 3 4 5

Any questions?

Now we are ready to being the statements.

FORM W

1. Doing science experiments is interesting.

2. In science I have fun with stuff and it's interesting.

3. Experimenting is fun.

4. Far too much time is wasted "just playing" with things in science.

5. I don't really like experimenting because I often don't know if I'm getting the <u>right</u> <u>answer</u>.

6. Doing science makes me notice that there are many beautiful things in the world.

7. Science makes me feel dumb.

8. By playing with batteries it helps me to get at all sorts of answers to question that bug me.

9. I'm glad when science periods are over.

Check your answer sheet to make sure that you are you are filling in the proper space.

FORM W (cont'd)

10. I wish we could play around with things in all subjects as we can in science.

11. A person <u>should</u> want to do science experiments so that he can learn about things that he has wondered about.

12. In science experiments, I don't have to pretend - I can be <u>myself</u>.

13. The sooner that I can forget about science experiments the happier I am.

14. Experiments are a bore.

15. Some things in science are beautiful and strange.

16. A person really <u>doesn't</u> learn much by fooling around with things in science.

17. People who like doing science experiments are creeps.

18. Science experiments are enjoyable.

19. I sometimes brag a little at home about what I did in science.

20. Science experiments are never <u>really</u> fun.

FORM X

21. Fooling around with things makes me want to learn more about them.

22. I'm still experimenting and thinking about something that I noticed in science a long time ago.

23. I don't care about <u>why</u> things happen in a science experiment.

24. A person doesn't get many ideas for an experiment from handling equipment.

25. If I noticed that a ball seemed to bounce about the same number of times if I dropped it from different heights, I'd go on and study something else.

26. It is nice to think about <u>ways</u> of discovering answers in experiments.

27. I really don't care why things happen the way they do.

FORM X (cont'd)

28. Anyone who goes to the library to get books about what he's noticed while playing around with things in science is a jerk.

29. If I can't find out why some strange things happen, it really bugs me.

30. If something unexpected happens in an experiment at another table, I don't think I'd bother going over there.

31. I want to discover more answers to things that bug me when we begin to experiment.

32. I'll work for hours on a science project if I think I've almost got an answer.

33. I wish we took a different unit every day.

34. I can think of a time when I did an experiment on my own because of something that I noticed.

FORM X (Cont'd)

35. Experiments are a challenge and I like to find out as many things as I can, before I go on to something else.

36. I don't think about science stuff unless I'm in class.

37. Although I know I should follow up more - from things that I notice in science, I usually don't bother.

38. If something is interesting I want to know what makes it tick even if it's hard work.

39. Once I've been introduced to an idea, I like to follow it up in an experiment.

40. Playing with things and messing around with things does not make me curious enough to experiment with them.

FORM Y

41. I hate trying to figure out why things work; I'd sooner just play with them and then forget them.

42. I often make up my own names for things so that I can remember and compare.

43. If you measure a lot, you discover things that you never noticed before.

44. Blowing bubbles is O.K. until the teacher starts asking a lot of question.

45. I hate trying to discover rules about why things happen in a certain way.

46. The confusion when I begin to experiment soon goes away as I plan what I'm going to do.

47. I think that for me to plan an experiment is a waste of time.

48. Playing with things is O.K. but I like to plan ways to find out more of the detail.

FORM Y (cont'd)

49. After playing with ice melting in water, I'd like to measure the temperature and graph how the temperature changes as the ice melts.

50. People overdo all this "measuring stuff" in science.

51. I'd rather think of things just as they are rather than by thinking about every part of them.

52. It's fun making up rules which might explain things you notice when you mess around with science stuff.

53. Having fun and measuring in science are two very different things.

54. If I experimented with pendulums, I would want to use a ruler and a timer.

55. If I was trying to find out how a mealworm explores a box I'd like to measure and record where he goes.

56. Experimenting can be fun, except I hate measuring and comparing.

FORM Y (cont'd)

57. When I experiment, I like to keep some sort of record in my book so I can compare things.

58. Science is fun until you have to compare things exactly.

59. I like discovering a pattern in something which didn't seem to have one.

60. Science would be more fun <u>without</u> rulers, graphs, and timers.

FORM Z

61. When I begin a new experiment I really get bugged when someone makes me stop.

62. It's neat to start right from the beginning of an experiment, doing everything for yourself.

63. I like subjects where the answers can be found easily in a book.

64. I'd like science a lot better if the teacher showed everyone how to do every experiment.

65. I wouldn't want to work with someone who usually told me the right answers.

66. I don't enjoy giving in and letting others do the work when we do an experiment.

67. I do extra experiments on my own.

68. I don't like the teacher to give away too many hints.

FORM Z (cont'd)

69. I wish the teacher would help me more so that I can do the right thing.

70. I'd sooner sit around and talk than play around with things in science.

71. I don't really like finding things out on my own.

72. I really like to watch the teacher do an experiment, instead of me doing one.

73. It's more <u>fun</u> hearing about science than doing it.

74. I like it best when I'm told how to do the experiment exactly so that I know how to find the right answer.

75. If my friends thought that my ideas were crazy, I don't think I'd say them.

76. It would be great to have more time to work on experiments that you choose and figure out on <u>your own</u>.

FORM Z (cont'd)

77. I'd rather do my very own experiments instead of watching the teacher do one.

78. Things get too confusing unless my teacher helps me.

79. I don't like the teacher to give away many clue.

80. I do a lot of experiments at home.

Scales with item-per-scale correlations (on left margin). Factors with Eigen values are labelled A, B,C, D, and E, (these are located in columns).

These factors seem to fit logically into the following classification:

A. FUN

\- Load — B. INSECURITY WHILE INVESTIGATING ON YOUR OWN

C. IMPOSING A STRUCTURE ON INVESTIGATIONS

\+ Load — D. INVESTIGATION BY "DOING YOU OWN" THING"

NOTE: Although Scale II does not appear too unique in factor analysis, it is logically different and has shown to discriminate differently from Scale I.

E. EGO IDENTIFICATION WITH SCIENCE

contributes little to the scales.

FORM W

ITEM-TEST CORRELATIONS	QUESTION	FACTORS: (A) FUN 17.52	(B) INSECURITY (invest) 3.60	(C) IMPOSING STRUCUTRE ON PLAY 3.27	(D) INDEPENDENCE (invest) 2.72	(E) EGO 2.60
.54623	1. Doing science experiments is interesting.	.60058	-.0555	-.06912	.06932	.09933
.53985	2. In science I have fun with stuff and it's interesting.	.42337	-.18112	-.33764	-.03545	.17773
.51513	3. Experimenting is fun.	.56009	-.16075	-.06260	-.00647	.12338
.19839	4. Far too much time is wasted "just playing with things in science.	.14409	-.02038	-.02904	-.09922	-.24244
.49467	5. I don't really like experimenting because I often don't know if I'm getting the right answer.	.38446	-.32006	-.20142	-.14893	.04735
.36343	6. Doing science makes me notice that there are many beautiful things in the world.	.32437	.06632	-.21060	-.02250	.15910
.38284	7. Science makes me feel dumb.	.22080	-.32647	-.08897	.19006	.01387

FORM W (Cont'd)

I.T.C.	QUESTION	(A)	(B)	(C)	(D)	(E)
.29686 E	8. By playing with batteries it helps me to get at all sorts of answers to questions that bug me.	.16883	.07882	-.19906	-.11107	.30352
.53719	9. I'm glad when science periods are over.	.38855	-.17182	-.13139	.03742	.18560
.23168 E	10. I wish we could play around with things in all subjects like we can in science.	.14967	.08139	.19179	-.03607	.34571
.36284	11. A person should want to do science experiments so that he can learn about things that he has wonder about.	.41204	.04046	-.05171	-.03529	-.14034
.33028	12. In science experiments, I don't have to pretend - I can be myself.	.32510	.07855	-.00739	.01929	.10385
.58122	13. The sooner that I can forget about science experiments the happier I am.	.39231	-.36395	-.23597	.17215	-.00844
.60703	14. Experiments are a bore.	.55657	-.19212	-.18754	.22554	.01759
.30313	15. Some things in science are beautiful and strange.	.33081	-.02382	.03720	.03796	-.01085
.36236 B	16. A person really doesn't learn much by fooling around with things in science.	.22650	-.38355	-.00196	-.12109	-.01028
.53448	17. People who like doing science experiments are creeps.	.43134	-.20635	-.70765	.37075	-.13102

I.T.C.	QUESTION	(A)	(B)	(C)	(D)	(E)
.62053	18. Science experiments are enjoyable.	.60991	-.07862	-.19459	.26091	.13742
.40271 E	19. I sometimes brag a little at home about what I did in science.	.19193	-.20764	-.06118	.07874	.42429
.63294	20. Science experiments are never really fun.	.58105	-.26814	-.11714	.18802	.01292
	FORM X					
.36884	21. Fooling around with things makes me want to learn more about them.	.39345	.16761	-.06777	.12394	.11566
.41060 E	22. I'm still experimenting and thinking about something I noticed in science a long time ago.	.13265	.03092	.01515	.22433	.44590
.59575	23. I don't care about why things happen in a science experiment.	.34327	-.23911	-.26478	.26880	.03828
.33445	24. A person doesn't get many ideas for an experiment from handling equipment.	.29694	-.09150	-.01605	-.01747	.06173
.24208	25. If I noticed that a ball seemed to bounce about the same number of times if I dropped it from different heights, I'd gon on and study something else.	.10771	-.25867	-.31402	-.10458	-.12563
.57977	26. It is nice to think about ways of discovering answers in experiments.	.55977	.09358	-.14776	.22145	.22265
.60992	27. I really don't care why things happen the way they do.	.49632	-.29880	-.17366	.15079	.05034

FORM X (cont'd)

I.T.C.	QUESTION	(A)	(B)	(C)	(D)	(E)
.51067	28. Anyone who goes to the library to get books about what he's noticed while playing around with things in science is a jerk.	.41633	-.07492	-.17052	.35282	-.26935
.39604	29. If I can't find out why some strange things happen, it really bugs me.	.43375	.12817	.01007	.14161	-.04007
.35485	30. If something unexpected happens in an experiment at another table, I don't think I'd bother going over there.	.36753	-.07649	-.02421	.29746	-.39016
.59290	31. I want to discover more answers to things that bug me when we being to experiment.	.50157	.05581	-.18161	.22622	.22461
.51863	32. I'll work for hours on a science project if I think I've almost got an answer.	.22594	-.09594	-.19170	.25493	.42867
.43051 C	33. I wish we took a different unit every day.	.16425	-.19220	-.29848	.27414	-.27107
.38263	34. I can think of a time when I did an experiment on my own because of something that I noticed.	.07367	-.12462	-.07236	.22517	.39285
.61475	35. Experiments are a challenge and I like to find out as many things as I can, before I go on to something else.	.52054	.02980	-.19344	.26333	.26967
.58758	36. I don't think about science stuff unless I'm in science class.	.36875	-.34019	-.19492	.14172	.08949

I.T.C.	QUESTION	(A)	(B)	(C)	(D)	(E)
.47451	37. Although I know I should follow up more - from things that I notice in science, I usually don't bother.	.31062	-.22379	-.37810	-.06808	.12690
.60654	38. If something is interesting I want to know what makes it tick even if it's hard work.	.41722	-.01908	-.32780	.09542	.26979
.61892	39. Once I've been introduced to an idea, I like to follow it up in an experiment.	.34686	-.00945	-.25664	.37986	.34743
.47744	40. Playing with things and messing around with things does not make me curious enough to experiment with them.	.40806	-.18300	-.20060	.10889	-.07108
	FORM Y					
.55789	41. I hate trying to figure out why things work; I'd sooner just play with them and then forget them.	.13501	-.26619	-.48816	.23840	.04915
.25789	42. I often make up my own names for things so that I can remember and compare.	.01873	.03843	-.23849	-.09382	.18265
.27994	43. If you measure a lot, you discover things that you never noticed before.	.11224	.27844	-.17150	.08342	.26516
.47828	44. Blowing bubbles is O.K. until the teacher starts asking a lot of questions.	.01461	-.18070	-.51885	-.04214	-.03676

I.T.C.	QUESTION	(A)	(B)	(C)	(D)	(E)
.48097	45. I hate trying to discover rules about why things happen in a certain way.	.03647	-.20694	-.40948	.19730	.13960
.40528	46. The confusion when I begin to experiment soon goes away as I plan what I'm going to do.	.13258	.19072	-.34189	.14161	.04407
.47630	47. I think that for me to plan an experiment is a waste of time.	.27585	-.17883	-.35147	.26655	-.08953
.48205	48. Playing with things is O.K. but I like to plan ways to find out more of the detail.	.17138	.18232	-.41290	.25148	.23467
.54235	49. After playing with ice melting in water, I'd like to measure the temperature and graph how the temperature changes as the ice melts.	.15393	.21927	-.48391	.25680	.08562
.46992	50. People overdo all this "measuring stuff" in science.	.4018	-.18584	-.42299	.17641	.0079
.57284	51. I'd rather think of things just as they are rather than by thinking about every part of them.	.10859	-.19702	-.53061	.10631	.04816
.42064	52. It's fun making up rules which might explain things you notice when you mess around with science stuff.	.05087	.02204	-.33312	.23297	.21521
.43806	53. Having fun and measuring in science are two very different things.	.10637	-.27228	-.34649	.03989	.1788

I.T.C.	QUESTION	(A)	(B)	(C)	(D)	(E)
.37516	54. If I experimented with pendulums, I would want to use a ruler and a timer.	.18053	.16790	-.37070	.02185	-.05394
.52413	55. If I was trying to find out how a mealworm explores a box I'd like to measure and record where he goes.	.17261	.16672	-.43277	.25422	.10650
.56373	56. Experimenting can be fun, except I hate measuring and comparing.	.00965	-.07877	-.61715	.1325	-.07345
.66362	57. When I experiment, I like to keep some sort of record in my book so I can compare things.	.17501	-.03897	-.62949	.22046	.05021
.43875	58. Science is fun until you have to compare things exactly.	.10351	-.08544	-.45483	-.07462	.10951
.46137	59. I like discovering a pattern in something which didn't seem to have one.	-.00308	-.00557	-.31490	-.39851	.19010
.62161	60. Science would be more fun without rulers, graphs, and timers.	.12810	.26633	.57229	.24052	-.07036

FORM Z

I.T.C.	QUESTION	(A)	(B)	(C)	(D)	(E)
.49645	61. When I begin a new experiment I really get bugged when someone makes me stop.	.19069	-.01778	-.07447	.49868	.25444
.54753	62. It's neat to start right from the beginning of an experiment, doing everything for yourself.	.18959	-.16980	-.14220	.49871	.15386
.51059	63. I like subjects where the answers can be found easily in a book.	.07880	-.52900	-.30542	.06967	.10593
.42587	64. I'd like science a lot better if the teacher showed everyone how to do every experiment.	-.02187	-.48862	-.04199	.20738	-.15674
.31766	65. I wouldn't want to work with someone who usually told me the right answers.	-.02927	.04357	-.15332	.42387	-.10251
.48508	66. I don't enjoy giving in and letting others do the work when we do an experiment.	.23687	.03218	-.07882	.61183	.02819
.45032	67. I do extra experiments on my own.	.07386	-.31926	-.18378	.01629	.56325
.55538	68. I don't like the teacher to give away too many hints.	-.01630	-.25859	-.02161	.65477	.04121
.38543 C	69. I wish the teacher would help me more so that I can do the right thing.	.09760	.54643	.02235	.10558	.10211

I.T.C.	QUESTION	(A)	(B)	(C)	(D)	(E)
.51362 C	70. I'd sooner sit around and talk than play around with things in science.	.25329	-.22626	-.42503	.19834	.05435
.52831	71. I don't really like finding things out on my own.	.06190	-.39102	-.18319	.27233	.13643
.62820	72. I really like to watch the teacher do an experiment, instead of me doing one.	.27863	-.36623	-.10943	.48832	-.02372
.50326	73. It's more fun hearing about science than doing it.	.34716	-.30990	-.15833	.25156	.01276
.48872	74. I like it best when I'm told how to do the experiment exactly so that I know how to find the right answer.	.10521	-.63646	-.06714	.01808	.09164
.42137	75. If my friends thought that my ideas were crazy, I don't think I'd say them.	.14423	-.40356	.01292	.13940	.0092
.44772	76. It would be great to have more time to work on experiments that you choose and figure out on your own.	.25968	-.05259	-.21380	.39406	.25460
.53559	77. I'd rather do my very own experiments instead of watching the teacher do one.	.18036	-.18205	-.05547	.46840	.05167
.43482	78. Things get too confusing unless my teacher help me.	-.04618	-.49689	-.1223	.15700	.04529

I.T.C.	QUESTION	(A)	(B)	(C)	(D)	(E)
.49953	79. I don't like the teacher to give away many clues.	.10186	-.19182	-.0666	.57139	.05096
.37842	80. I do a lot of experiments at home.	.11532	-.25130	-.14246	-.004	.6506

PROGRAMME ONE

This programme converts the optical scanner output to proper-size mode. The blank items become scored as undecided. Data is then written according to the format (12X, 60A1/12X, 60A1). Logical unit "6" tells where this modified data is to be written (in this case in file "A").

```
$RUN *FORTRAN
       DIMENSION I(80), M(11)
       DATA M/'0','1','2','3','4','5','6','7','8','9',' '/
     5 READ (5, 10, END=80)I
    10 FORMAT (12X,60A./12X,60A1)
       DO 20 J=1, 79, 2
       IF(I(J).EQ.M(11))I(J)+M(3)
       IF(I(J+1).EQ.M(11))I(J+1)=M(8)
       DO 20 K=6, 10
       IF(I(J+1).EQ.M(K))I(J+1)=M(K=5)
    20 CONTINUE
       WRITE (6,10)I
       GOTO5
    80 STOP
       END
$ENDFILE
$RUN-LOAD# 6=A
```

PROGRAMME TWO

This programme reverses the negative items and then sums the four attitude scales independently and also gives a total score as well. Following the $Endfile card is the list of negative items (items for reverse scoring). The original responses are read from a file entitled -B.

C1 'Subjec' is a vector of items whose value is to be reversed.

C1 'Data' is a matrix of all the data with a row for each student.

C1 'Data' is a matrix of all the data with a row for each student and a column for each question.

C1 "tot" is a vector of subtest scores.

C2 Read in items to be reversed.

C6 Read in data.

C9 Reverse the required items.

```
$RUN *FORTRAN

      INTEGER SUBJEC(80),DATA(184,80),TOT(5)
      READ (5,5,END=10)   (SUBJEC(I),I=1,80)
    5 FORMAT(13)
   10 NITEMS=I-1
      DO 25 I=1,184
      READ(6,15)(DATA(I,J),J=1,80)
```

```
   15  FORMAT(12X,60I1/12X,60I1) (or any modification)
       DO 20 J=1, NITEMS
       DATA (I-SUBJEC(J))=IABS(DATA(I,SUBJEC(J))-4)
   20  CONTINUE
       DO 220 J=1,80
  220  DATA(I,J)=IABS(DATA(I,J)-4)
       TOT(5)=0
       M=1
       J=1
       K=20
   21  TOT(M)=0
       DO 22 L=J,K
       TOT(M)=TOT(M)+DATA(I,L)
   22  CONTINUE
       M=M+1
       IF(M,GE.5) GO TO 23
       J=K+1
       K=K+20
       GO TO 21
   23  DO 24 M=1,4
       TOT(5)=TOT(5)+TOT(M)
   24  CONTINUE
       WRITE(8,26) TOT
   26  FORMAT(5I7)
   25  CONTINUE
       DO 40 I=1,184
       WRITE(6,30)  (DATA(I,J),J=1,80)
   30  FORMAT(12X,60I1/12X,60I1) (or any modification)
   40  CONTINUE
       STOP
       END

$RUN - LOAD# 6=-B 8=-H

    4
    5
    7
    9
   13
   14
   16  These are the negative items:
   17  one I3 format numeral on each
   20  card.
   23
   24
   25
   27
```

```
   28  (list of items for reversed scoring)
   30
   33
   36
   37
   40
   41
   44
   45
   47
   50
   51
   53
   56
   58
   60
   63
   64
   69
   70
   71
   72
   73
   74
   75
   78
ENDFILE
```

APPENDIX C

ITEM AND TEST ANALYSES FOR C.E.F.T. AND THE TEST OF SCIENCE PROCESSES

Table C1

Item Analysis of the Childrens' Embedded Figures Test

Item No.	Point Biserial	P	Variance
1	0.4388	0.7486	0.1882
2	0.3266	0.6667	0.2222
3	0.3960	0.6393	0.2306
4	0.1362	0.8251	0.1443
5	0.2796	0.8470	0.1296
6	0.4962	0.6339	0.2321
7	0.3922	0.8962	0.0930
8	0.1346	0.3770	0.2349
9	0.3310	0.8689	0.1139
10	0.4503	0.8197	0.1478
11	0.5087	0.5738	0.2446
12	0.4438	0.8525	0.1258
13	0.4414	0.4044	0.2409
14	0.4766	0.6831	0.2165
15	0.4612	0.8415	0.1334
16	0.4506	0.7978	0.1613
17	0.5295	0.6721	0.2204
18	0.4865	0.7705	0.1768
19	0.4952	0.5410	0.2483
20	0.3494	0.5355	0.2487
The Mean is 13.9945			
The KR-20 is 0.7238			
The standard deviation is 3.4665			

Continued

*The first five items have been omitted from the analysis of items because of the method suggested in the manual for the administration of C.E.F.T. to this age group. Considering the total test of twenty-five items:

Total Group: $\overline{X} = 18.86$

$\sigma = 3.58$

Boys Group: $\overline{X} = 18.77$

$\sigma = 3.71$

Girls Group: $\overline{X} = 18.96$[1]

$\sigma = 3.46$

---

[1]Note: there were no "clear-cut" sex differences on C.E.F.T. scores.

Table C2

Item Analysis for Subtests of the

Test of Science Processes

D6: OBSERVING

Item No.	Point Biserial	P	Variance
13	0.4378	0.7717	0.1762
14	0.5340	0.7065	0.2073
15	0.4893	0.5380	0.2486
16	0.4148	0.6957	0.2117
17	0.3075	0.7446	0.1902
18	0.5512	0.5815	0.2434
19	0.5269	0.4457	0.2470
20	0.5471	0.2935	0.2073
21	0.4636	0.5543	0.2470

The Mean is 5.3315

The KR-20 is 0.5736

The Standard Deviation is 2.0092

D7: COMPARING

Item No.	Point Biserial	P	Variance
3	0.5938	0.5761	0.2442
7	0.5249	0.7772	0.1732
22	0.5122	0.8967	0.0926
23	0.4426	0.3315	0.2216
24	0.5019	0.9076	0.0839

The Mean is 3.4891

The KR-20 is 0.2730

The Standard Deviation is 1.0214

D8: CLASSIFYING

Item No.	Point Biserial	P	Variance
1	0.2741	0.9511	0.0465
2	0.2202	0.8587	0.1213
4	0.3305	0.7880	0.1670
5	0.3470	0.7174	0.2027
6	0.3850	0.9348	0.0610
9	0.4857	0.2283	0.1762
10	0.4803	0.2989	0.2096
11	0.4417	0.4293	0.2450
25	0.2689	0.8859	0.1011
26	0.4088	0.8750	0.1094
27	0.4165	0.7772	0.1732
28	0.3203	0.7772	0.1732
29	0.4387	0.6630	0.2234

The Mean is 9.1848

The KR-20 is 0.4798

The Standard Deviation is 1.8993

D9: QUANTIFYING

Item No.	Point Biserial	P	Variance
30	0.3579	0.9674	0.0315
31	0.3326	0.8098	0.1540
32	0.5544	0.6957	0.2117
33	0.4156	0.6685	0.2216
34	0.2835	0.8641	0.1174
35	0.5774	0.6685	0.2216
36	0.5104	0.8478	0.1290
37	0.3578	0.3696	0.2330
38	0.4799	0.6739	0.2198
39	0.4446	0.8804	0.1053
40	0.4647	0.8207	0.1472
41	0.4209	0.9620	0.0366

The Mean is 9.2283

The KR-20 is 0.5911

The Standard Deviation is 1.9978

D10: MEASURING

Item No.	Point Biserial	P	Variance
42	0.4759	0.6359	0.2315
43	0.3269	0.9130	0.0794
44	0.4277	0.7174	0.2027
45	0.2692	0.7337	0.1954
46	0.3493	0.8207	0.1472
47	0.2359	0.6793	0.2178
48	0.4594	0.7065	0.2073
49	0.3921	0.4239	0.2442
50	0.3447	0.7174	0.2027
51	0.4251	0.6250	0.2344
52	0.2209	0.1957	0.1574
53	0.2711	0.1957	0.1574
54	0.4812	0.7228	0.2003
55	0.5031	0.7337	0.1954
56	0.4499	0.6087	0.2382
57	0.4716	0.5054	0.2500
58	0.3902	0.5707	0.2450
59	0.5072	0.5978	0.2404
60	0.1539	0.6087	0.2382
61	0.3486	0.7663	0.1791
62	0.3486	0.7663	0.1791
63	0.5401	0.5380	0.2486
64	0.4889	0.6359	0.2315
65	0.2117	0.2772	0.2003
66	0.3292	0.3261	0.2198

The Mean is 14.6848

The KR-20 is 0.7567

The Standard Deviation is 4.3637

D11: EXPERIMENTING

Item No.	Point Biserial	P	Variance
67	0.3516	0.4674	0.2489
68	0.2911	0.5109	0.2499
69	0.1763	0.3152	0.2159
70	0.3873	0.3859	0.2370
71	0.5113	0.4511	0.2476
72	0.4610	0.4891	0.2499
74	0.3955	0.6032	0.2393
75	0.4536	0.6739	0.2198
76	0.4133	0.6033	0.2393
77	0.3610	0.5326	0.2489

The Mean is 5.0326

The KR-20 is 0.3453

The Standard Deviation is 1.8647

D12: INFERRING

Item No.	Point Biserial	P	Variance
12	0.3592	0.3641	0.2315
73	0.4162	0.2446	0.1848
78	0.2709	0.3967	0.2393
79	0.2531	0.4837	0.2497
80	0.4015	0.4924	0.2415
81	0.2245	0.2065	0.1639
82	0.4031	0.8641	0.1174
83	0.3504	0.5272	0.2493
85	0.4336	014891	0.2499
86	0.3335	0.3098	0.2138
92	0.4541	0.4978	0.2404
94	0.4773	0.4402	0.2464
95	0.2978	0.4163	0.2497
96	0.4921	0.6359	0.2315

The Mean is 6.6685

The KR-20 is 0.5090

The Standard Deviation is 2.4281

D13: PREDICTING

Item No.	Point Biserial	P	Variance
8	0.4170	0.7120	0.2051
84	0.4063	0.4457	0.2470
87	0.4212	0.6793	0.2178
88	0.4843	0.6957	0.2117
89	0.4570	0.3967	0.2393
90	0.4990	0.3587	0.2300
91	0.4730	0.6033	0.2393
93	0.2401	0.4946	0.2500

The Mean is 4.3859

The KR-20 is 0.3459

The Standard Deviation is 1.6245

Item Analysis of the Total

Test of Science

Processes

D14: PROCESSES

Item No.	Point Biserial	P	Variance
1	0.1818	0.9511	0.0465
2	0.2005	0.8587	0.1213
3	0.1808	0.5761	0.2442
4	0.2514	0.7880	0.1670
5	0.2547	0.7174	0.2027
6	0.2792	0.9348	0.0610
7	0.3221	0.7772	0.1732
8	0.1334	0.7120	0.2051
9	0.1999	0.2283	0.1762
10	0.1804	0.2989	0.2096
11	0.2233	0.4293	0.2450
12	0.2870	0.3641	0.2315
13	0.3984	0.7717	0.1762
14	0.4307	0.7065	0.2073
15	0.4341	0.5380	0.2486
16	0.2652	0.6957	0.2117
17	0.2798	0.7446	0.1902
18	0.4387	0.5814	0.2434
19	0.3263	0.4457	0.2470
20	0.4273	0.2935	0.2073
21	0.2647	0.5543	0.2470
22	0.3583	0.8967	0.0926
23	0.2870	0.3315	0.2216
24	0.3363	0.9076	0.0839
25	0.2751	0.8859	0.1011
26	0.3948	0.8750	0.1094
27	0.2383	0.7772	0.1732
28	0.1814	0.7772	0.1732
29	0.3539	0.6630	0.2234
30	0.2959	0.9674	0.0315
31	0.2384	0.8098	0.1540
32	0.4440	0.6957	0.2117
33	0.3416	0.6685	0.2216
34	0.2076	0.8641	0.1174

Item No.	Point Biserial	P	Variance
35	0.4688	0.6685	0.2216
36	0.4067	0.8478	0.1290
37	0.2968	0.3696	0.2330
38	0.3210	0.6739	0.2198
39	0.3440	0.8804	0.1053
40	0.3078	0.8207	0.1472
41	0.2928	0.9620	0.0366
42	0.4201	0.6359	0.2315
43	0.3609	0.9130	0.0794
44	0.3408	0.7174	0.2027
45	0.2439	0.7337	0.1954
46	0.3292	0.8207	0.1472
47	0.1193	0.6793	0.2178
48	0.4165	0.7065	0.2073
49	0.3849	0.4239	0.2442
50	0.2872	0.7174	0.2027
51	0.3509	0.6250	0.2344
52	0.1789	0.1957	0.1574
53	0.1811	0.1957	0.1574
54	0.4073	0.7228	0.2003
55	0.4855	0.7337	0.1954
56	0.4337	0.6087	0.2382
57	0.4777	0.5054	0.2500
58	0.3110	0.5707	0.2450
59	0.4404	0.5978	0.2404
60	0.1133	0.6087	0.2382
61	0.3035	0.7663	0.1791
62	0.3903	0.4293	0.2450
63	0.4108	0.5380	0.2486
64	0.4139	0.6359	0.2315
65	0.1932	0.2772	0.2003
66	0.2616	0.3261	0.2198
67	0.1705	0.4674	0.2489
68	0.0883	0.5109	0.2499
69	-0.0151	0.3152	0.2159
70	0.2474	0.3859	0.2370
71	0.4731	0.4511	0.2476
72	0.3684	0.4891	0.2499
73	0.2954	0.2446	0.1848
74	0.1764	0.6033	0.2393
75	0.2612	0.6739	0.2198

Item No.	Point Biserial	P	Variance
76	0.2213	0.6033	0.2393
77	0.2749	0.5326	0.2489
78	0.1264	0.3967	0.2393
79	0.1470	0.4837	0.2497
80	0.3606	0.5924	0.2415
81	0.1360	0.2065	0.1639
82	0.3584	0.8641	0.1174
83	0.2446	0.5272	0.2493
84	0.1079	0.4457	0.2470
85	0.3718	0.4891	0.2499
86	0.2428	0.3098	0.2138
87	0.3261	0.6793	0.2178
88	0.3878	0.6957	0.2117
89	0.3140	0.3967	0.2393
90	0.3894	0.3587	0.2300
91	0.3604	0.6033	0.2393
92	0.4194	0.5978	0.2404
93	0.0203	0.4946	0.2500
94	0.3727	0.4402	0.2464
95	0.2797	0.5163	0.2497
96	0.3969	0.6359	0.2315

The Mean is 58.0054

The KR-20 is 0.8887

The Standard Deviation is 12.6179

APPENDIX D

RAW DATA--IDENTIFIED ACCORDING TO FORMAT

1	01112171	08421	316	6	3	09	09	18	6	07	6	64	59	56	55	48	218	19	34	15
2	02112158	10018	213	5	3	09	08	09	7	06	3	50	61	48	42	34	185	21	17	00
3	03111161	09820	315	8	3	08	09	12	7	10	6	63	70	67	62	44	243	15	30	15
4	04111155	12020	315	6	4	08	11	18	7	08	7	69	65	60	37	47	209	38	39	01
5	05111153	09923	318	3	2	05	08	15	2	03	2	40	61	62	62	49	234	14	20	06
6	06112162	11019	214	7	4	09	12	20	7	11	6	76	67	57	56	53	233	40	44	04
7	07112168	09722	317	3	5	09	08	12	6	08	7	53	39	51	27	48	165	22	34	12
8	08112167	08617	212	5	2	07	09	08	5	06	3	45	61	53	34	48	196	15	22	07
9	09111151	12317	212	7	5	09	10	16	2	07	5	61	54	58	64	60	236	36	42	06
10	10112161	10323	318	5	4	09	09	18	5	07	5	62	54	56	51	50	211	28	33	05
11	11111155	12620	315	7	3	09	12	16	8	04	6	65	58	51	33	46	188	32	31	00
12	12112163	12321	316	9	5	13	08	20	7	09	7	78	50	58	46	37	191	36	38	02
13	13112155	10514	109	4	4	11	07	11	6	06	2	51	70	54	59	34	217	26	31	05
14	14111152	11416	211	7	4	10	10	17	8	04	2	62	55	39	35	38	167	29	37	08
15	15112150	11419	214	7	5	09	10	18	5	07	3	64	65	41	33	47	186	31	37	06
16	16111186	11419	214	7	3	09	09	15	5	08	5	61	62	66	54	63	245	15	24	09
17	17112152	11222	317	6	5	09	11	16	8	06	5	68	68	53	27	49	197	26	32	06
18	18112160	10113	108	5	3	08	10	14	6	05	3	54	57	57	53	54	221	25	31	06
19	19111155	13125	320	8	4	10	12	23	5	09	6	77	75	71	67	72	285	37	37	00
20	20112170	10022	317	7	4	11	05	10	5	08	8	58	51	59	35	11	156	35	36	01
21	21112156	09419	214	4	4	11	09	09	6	05	5	53	47	57	57	33	194	13	18	00
22	22112163	08815	110	0	2	08	06	07	3	01	2	29	39	34	34	28	135	10	11	01
23	23111157	09615	110	5	3	08	09	11	5	04	3	48	61	63	47	48	219	26	29	03
24	24112160	11125	320	7	5	09	10	13	5	06	6	61	43	29	13	56	141	27	34	07
25	25112167	10722	317	7	4	10	09	13	4	06	5	58	58	52	45	56	211	26	31	06
26	26112150	11222	317	8	3	10	11	13	7	09	6	67	67	56	50	62	235	26	30	04
27	01121161	10413	108	6	3	08	05	13	6	05	4	50	41	24	34	35	134	17	20	03
28	02121177	09424	319	9	3	10	09	15	7	09	5	67	76	71	79	80	306	20	24	04
29	03121150	10014	109	8	3	09	11	14	7	07	5	64	54	35	15	29	133	31	36	05
30	04122150	10722	317	5	3	06	08	08	2	09	0	41	53	43	47	55	198	20	28	03

IDENTIFICATION OF DATA VIA "F" FORMAT - CONSECUTIVELY LABELLED:

(1) F 2.0 = Class number
(2) F 1.0 = Year(first analysis of variance classification.)
(3) F 1.0 = Division within the year.
(4) F 1.0 = Sex (1=boy, 2=girl).
(5) F 3.0 = Age
(6) F 3.0 = I.Q.
(7) F 1.0 = Actual CEFT Score.
(8) F 1.0 = Second analysis of variance classification according to CEFT score.
(9) F 2.0 = original CEFT score (Tot=20) - alternate scoring method.
(10) F 1.0 = Observing
(11) F 1.0 = Comparing
(12) F 2.0 = Classifying
(13) F 2.0 = Quantifying
(14) F 2.0 = Measuring
(15) F 1.0 = Experimenting.
(16) F 2.0 = Inferring.
(17) F 1.0 = Predicting
(18) F 2.0 = Total Science Processes
(19) F 2.0 = Fun Attitude
(20) F 2.0 = Pursue Attitude
(21) F 2.0 = Structure Attitude
(22) F 2.0 = Individual Investigation Att
(23) F 3.0 = Total Attitude Score
(24) F 2.0 = Sept. Reading
(25) F 2.0 = June Reading
(26) F 2.0 = Reading Gain Score

31	05121155	10019	214	2	3	11	07	13	3	07	6	52	45	36	42	46	169	24	34	10
32	06121152	11123	318	7	4	10	08	15	4	09	5	62	56	52	50	49	207	27	38	11
33	07122157	10619	215	7	3	10	08	10	5	03	3	49	59	47	37	63	206	27	38	11
34	08121156	10822	317	5	3	10	09	18	6	10	6	67	25	10	20	13	073	32	32	00
35	09121175	09124	319	5	4	09	06	17	3	03	3	52	28	45	41	43	157	19	20	01
36	10122151	11920	315	6	3	11	11	17	3	06	3	60	65	60	53	55	233	13	20	07
37	11121152	09921	316	5	3	08	07	11	0	05	3	42	54	42	40	63	199	19	29	10
38	12121157	10618	214	2	1	11	08	10	6	06	5	49	56	54	49	53	212	20	31	11
39	13122165	09413	108	4	2	09	08	06	3	04	4	40	33	44	45	33	155	30	31	01
40	14121161	10514	109	7	4	08	11	18	2	06	6	62	65	56	46	59	226	10	20	10
41	15121162	09621	316	5	4	08	10	21	7	07	5	67	52	40	32	40	164	19	29	10
42	16122149	11419	214	3	5	09	10	14	7	08	4	58	39	17	18	26	100	23	23	05
43	17122153	09919	214	5	3	10	09	07	4	05	5	48	60	50	48	52	210	21	23	02
44	18121150	11121	316	8	3	09	09	16	6	08	4	63	65	50	39	59	213	27	34	07
45	19122169	09617	212	5	3	09	08	10	3	04	3	45	47	35	37	38	157	19	27	08
46	20121155	10519	214	6	3	12	07	11	4	07	5	55	60	53	34	56	203	26	25	01
47	21121167	09822	317	5	2	08	08	13	4	05	5	50	40	28	28	34	130	19	25	06
48	22122174	08619	214	2	3	07	09	08	4	05	3	41	51	42	41	24	158	13	12	00
49	23122155	11023	318	6	3	11	11	12	3	08	4	58	58	61	51	64	234	35	35	00
50	24121159	11422	317	6	4	09	09	18	4	08	1	59	50	61	16	55	182	35	38	03
51	25122147	14820	315	9	4	13	12	19	7	11	6	81	48	56	24	48	176	41	41	00
52	26121155	10023	318	8	3	09	10	12	5	02	1	50	54	55	52	61	222	22	27	05
53	27121175	09619	214	5	4	10	07	11	5	05	4	51	56	51	48	61	216	15	15	00
54	28122201	09120	315	4	4	08	09	10	4	04	4	47	70	73	57	56	256	29	35	06
55	29121152	10020	315	6	4	09	11	15	4	07	4	60	53	57	64	47	221	19	25	06
56	30122147	11222	317	6	4	08	10	18	6	10	3	65	42	52	47	43	184	27	36	09
57	31122159	10319	214	3	4	10	07	10	2	07	4	47	64	64	44	55	227	22	35	13
58	32121147	13622	317	9	4	11	12	19	4	07	5	71	06	48	40	34	188	40	37	00
59	01212158	09719	214	5	4	08	10	12	2	05	5	51	57	58	50	46	211	15	24	09
60	02211167	10725	320	4	3	10	08	15	4	06	3	53	33	32	48	35	148	26	25	00
61	03211155	10320	315	8	4	7	09	17	6	06	4	61	56	63	58	50	227	22	32	10
62	04211157	12321	316	6	5	11	12	17	9	09	5	74	59	56	49	50	214	32	36	04
63	05212149	12014	110	5	3	10	12	19	6	10	4	69	54	47	31	38	170	34	35	01
64	06211159	10618	213	6	5	10	11	23	4	05	3	67	62	50	53	47	212	28	27	00
65	07211155	10520	315	4	1	07	08	12	2	07	2	43	54	44	36	39	173	30	36	06
66	08211154	13021	316	9	5	13	11	25	8	12	5	88	50	48	45	53	196	41	44	03
67	09211156	09516	211	5	4	09	08	13	2	08	6	55	58	65	37	42	202	20	30	10
68	10211150	11921	316	7	3	10	11	20	4	10	6	71	63	61	51	54	229	39	36	00
69	11211156	10613	108	4	4	08	09	16	4	06	6	57	48	26	38	14	126	31	20	00
70	12211150	11818	213	5	5	07	12	20	5	09	5	68	63	48	50	44	205	26	28	02
71	13212155	11913	108	7	4	10	10	19	8	09	5	72	48	49	55	38	190	30	38	08
72	14212161	10014	109	3	5	09	09	11	6	07	4	54	50	45	35	42	172	21	29	08
73	15211167	08410	105	2	3	05	06	08	2	04	1	31	47	52	56	46	201	13	13	00
74	16211150	10620	315	3	4	09	11	11	3	06	2	49	42	45	43	56	186	24	22	02
75	18212153	10918	215	4	4	12	11	16	4	09	5	65	59	53	35	44	191	26	29	03
76	19211154	12517	213	9	4	11	12	20	4	09	5	74	54	40	34	51	179	37	33	09
77	20211155	092 8	104	3	4	05	08	14	4	03	3	44	42	36	34	26	138	27	22	00
78	21212151	10013	108	5	4	08	07	11	3	05	5	48	64	45	42	43	194	20	22	02
79	01222163	09118	213	4	2	06	09	15	6	07	4	53	62	60	66	64	252	23	26	03
80	02221156	12221	316	8	5	10	09	16	5	08	4	65	44	37	12	19	112	37	35	00
81	03221164	10016	213	4	4	10	10	15	6	07	4	60	68	69	72	57	266	29	29	00
82	04221153	09715	111	1	2	06	04	08	7	03	3	34	33	38	15	35	121	20	32	10
83	05221154	11922	317	7	4	11	12	14	9	10	8	75	55	52	56	64	227	37	32	00
84	06221160	10922	317	4	4	09	11	14	4	06	1	53	67	64	72	64	267	31	35	04
85	07221151	13218	213	7	4	13	11	21	8	09	7	80	52	56	56	59	223	37	35	00
86	08221152	12721	316	8	5	08	10	17	8	08	3	67	69	64	60	60	253	36	41	05
87	09221160	10313	108	4	3	09	09	14	6	06	3	54	62	42	29	14	147	32	29	00
88	10221161	09320	315	2	0	07	08	14	2	03	2	38	40	57	31	37	165	33	27	00
89	12221163	09511	106	5	3	08	06	15	4	03	1	45	56	32	23	41	157	14	14	00
90	13222156	10216	211	6	3	09	09	15	6	05	5	53	30	13	20	06	069	31	36	05

91	14222164	09910	106	4	2	05	05	07	5	04	2	34	54	58	34	31	177	15	12	00
92	15221172	09518	213	8	3	08	09	18	3	03	2	54	57	56	44	52	209	28	22	00
93	16222157	09717	212	4	3	09	07	09	3	04	3	42	58	56	45	36	195	23	21	00
94	17222161	09520	315	5	3	08	07	09	5	07	6	50	45	50	31	18	144	28	28	00
95	18221160	09616	211	4	4	08	10	15	4	08	7	60	49	62	39	50	200	25	27	02
96	19221189	09219	214	4	4	10	08	17	5	07	3	58	66	68	40	63	237	18	20	02
97	20221162	09415	111	3	3	06	07	11	4	07	4	45	60	46	37	34	177	23	23	00
98	21222166	09917	212	7	4	08	08	15	5	08	6	61	69	57	57	35	218	15	27	12
99	22222156	11819	214	8	4	09	08	15	8	10	5	67	51	60	50	66	227	35	37	02
100	01231176	09213	108	5	4	08	08	09	4	05	4	47	52	34	48	59	193	14	24	10
101	02231157	11724	319	6	3	10	12	15	4	08	5	63	36	16	30	29	111	36	39	03
102	03231153	13122	317	8	4	10	12	19	6	07	5	71	43	43	29	36	151	42	45	03
103	04231150	11819	214	7	2	08	10	18	3	04	4	56	36	50	34	37	157	31	38	07
104	05232182	08820	315	1	1	09	07	09	6	04	4	41	47	45	57	39	183	19	29	10
105	06232150	11621	316	8	3	11	11	14	5	09	7	68	58	57	65	40	220	34	37	03
106	07232177	09217	212	5	4	08	08	06	3	02	4	40	42	43	47	38	170	15	14	00
107	08231151	12521	316	7	4	13	12	19	8	08	4	75	64	49	30	37	180	34	43	09
108	09231149	12823	318	9	3	09	11	20	6	11	7	76	53	50	43	53	199	36	39	03
109	10232160	11122	317	6	4	09	11	17	6	10	4	67	69	65	52	64	250	24	35	11
110	11231160	12320	315	9	5	12	12	25	6	13	6	88	67	62	60	70	259	41	43	02
111	13232155	12020	315	6	3	11	12	15	5	09	6	67	68	65	53	56	242	30	36	06
112	14232149	14223	318	8	5	13	11	21	8	10	6	82	48	44	60	56	208	42	42	00
113	15232149	11824	319	8	4	08	11	16	7	07	4	65	29	20	13	11	073	35	37	02
114	16231160	09917	213	4	3	05	08	17	6	08	5	56	72	66	68	57	263	14	24	10
115	17232164	09111	108	3	4	08	09	10	4	06	4	48	65	65	28	47	205	17	19	02
116	18232154	12123	318	6	3	12	10	20	6	09	5	71	41	40	38	50	169	37	39	02
117	19232152	12523	318	6	5	10	08	17	4	09	7	66	67	56	45	62	230	41	42	01
118	20231159	13123	318	8	4	13	10	21	8	09	2	75	63	52	41	49	205	41	41	00
119	21232153	12223	318	7	4	12	10	20	7	11	6	77	67	59	32	47	205	25	36	11
120	22232156	12920	315	3	4	10	10	17	6	09	5	64	53	54	49	53	209	34	41	07
121	23231166	09718	215	3	2	06	10	10	4	06	4	45	45	52	46	20	163	20	29	09
122	24232153	12522	317	7	3	09	09	18	8	06	2	62	58	61	36	46	201	36	38	02
123	25232153	11516	211	6	4	09	10	17	5	10	4	65	67	40	50	44	201	21	35	14
124	26231167	09622	317	6	5	11	10	17	5	07	3	64	55	46	51	51	203	42	27	00
125	27232154	11217	212	7	4	08	10	18	7	11	7	72	67	62	55	56	240	28	40	12
126	28231167	09214	111	3	2	09	08	10	5	03	3	43	38	37	39	26	140	16	31	1
127	29231161	12822	317	5	4	10	12	22	8	04	6	71	74	77	69	67	287	32	38	06
128	30232150	12123	318	7	4	10	11	23	6	10	6	77	47	53	39	41	180	41	37	06
129	01312155	11419	214	3	4	10	07	16	6	05	2	53	55	33	17	46	151	25	30	05
130	02311158	10225	320	4	3	10	10	15	6	07	3	58	58	49	35	50	192	27	29	02
131	03311151	09624	319	3	3	09	10	15	3	04	3	50	28	18	24	10	080	20	14	00
132	04311172	10322	317	5	4	08	11	18	4	07	6	63	42	45	41	35	163	22	14	00
133	05311152	12917	212	8	5	10	12	23	7	11	5	81	71	72	58	75	276	31	33	02
134	06311149	11821	316	6	3	09	12	21	6	10	4	71	68	54	56	53	231	27	33	06
135	07311165	09521	316	9	2	09	11	21	7	08	5	72	64	58	55	54	231	19	25	05
136	08311169	09020	315	3	4	09	11	13	6	02	7	55	66	38	26	37	167	18	19	01
137	09311159	10820	315	5	3	11	06	20	5	06	6	62	46	38	45	43	172	30	34	04
138	10311154	11914	109	4	3	08	06	09	1	05	4	40	38	37	20	29	124	36	33	0
139	11312170	09822	317	7	3	10	11	21	8	09	8	77	65	53	34	39	191	17	24	0
140	12312170	08420	315	3	2	06	06	08	7	05	2	39	47	65	40	50	202	12	19	0
141	13312155	11625	320	4	4	13	08	12	4	08	4	57	53	60	37	29	179	25	30	0
142	14312154	10217	212	5	4	11	11	14	8	08	6	67	50	57	31	44	182	23	33	1
143	15311159	12022	317	7	4	13	11	19	5	11	6	76	72	71	64	47	254	38	41	0
144	16312154	10918	214	6	3	10	10	16	7	06	7	65	57	48	27	27	159	26	41	1
145	17311162	09416	211	1	0	08	05	03	1	07	4	29	40	22	27	26	115	12	14	0
146	18312160	09012	107	0	2	03	02	08	4	02	3	24	44	38	48	24	154	20	21	0
147	19311169	09721	316	6	5	10	11	17	5	06	3	63	63	67	44	50	224	19	24	0
148	20311174	07812	107	2	4	04	05	14	3	02	4	38	42	41	34	40	157	16	15	0
149	21312162	11216	212	6	4	08	10	18	7	11	6	70	62	76	75	51	264	36	39	0
150	22312152	09721	316	5	4	09	09	16	4	05	4	56	61	57	46	55	219	20	23	0

151	23312153	12923	318	7	5	13	11	21	7	08	8	80	61	56	51	53	221	36	40	04
152	24312156	10220	315	5	4	10	11	17	7	07	3	64	49	40	30	49	168	17	22	05
153	25311167	07612	109	6	2	10	04	07	5	02	4	40	40	49	37	33	159	14	15	01
154	26312152	12021	316	6	3	12	10	19	5	09	7	71	58	50	38	43	189	37	36	00
155	27312164	08213	108	1	2	06	11	09	3	06	2	40	28	33	29	35	122	17	22	05
156	28312168	08816	211	2	1	07	05	11	7	03	2	38	46	44	22	16	128	12	16	04
157	29311159	13016	211	5	3	11	12	19	6	09	6	71	67	61	46	53	232	40	40	00
158	01322162	11424	319	6	3	12	10	17	2	05	4	59	69	71	65	61	266	27	31	14
159	02321165	09818	213	2	5	08	09	12	3	03	2	44	59	76	72	59	266	18	20	02
160	03322157	11319	214	7	4	12	10	15	1	05	5	59	60	60	47	38	205	31	32	02
161	04322151	10719	214	3	4	08	08	11	2	05	4	45	51	60	55	46	212	18	20	02
162	05321155	10514	109	6	2	06	09	14	3	08	3	51	55	38	42	48	183	17	23	05
163	06321156	09718	213	7	4	08	11	10	3	05	4	52	64	56	29	47	196	20	17	00
164	07321161	11021	316	3	3	10	10	16	7	04	4	57	59	48	48	47	202	36	39	01
165	08321157	09716	211	3	4	07	08	11	5	04	5	47	70	66	60	58	254	12	14	02
166	09322157	10424	319	5	4	09	10	17	5	07	6	63	38	53	48	35	174	21	20	00
167	10321158	12424	319	6	4	10	08	16	6	07	4	61	42	27	41	36	146	28	39	11
168	11322171	09516	211	6	3	11	11	13	4	05	5	58	39	34	50	30	153	26	24	00
169	12322168	10917	212	6	4	09	10	15	4	07	2	57	67	63	53	47	230	33	28	00
170	13321156	10217	213	3	4	08	09	15	4	05	3	51	74	71	47	50	242	18	23	05
171	14322165	09515	110	3	3	09	09	12	3	05	3	47	39	35	35	47	156	14	15	01
172	15321182	09318	213	5	4	10	09	17	5	08	6	64	64	63	63	44	234	24	26	02
173	16321164	09915	110	3	3	09	08	17	5	05	5	55	44	44	36	24	148	22	23	01
174	17321171	09113	108	3	5	09	07	12	3	04	3	46	53	62	46	56	217	27	24	00
175	18321163	10315	110	3	1	04	02	03	4	01	4	22	58	51	62	49	220	24	26	02
176	19322151	11619	214	5	4	10	11	12	3	09	6	60	66	56	54	57	233	49	23	00
177	20322153	11219	214	6	4	08	12	20	7	08	6	71	34	30	28	17	109	31	31	00
178	21322158	10723	318	6	5	13	11	14	7	05	6	67	62	59	67	59	247	29	39	10
179	22322154	11220	315	4	4	10	09	17	5	05	3	57	64	62	58	50	234	29	33	04
180	23322157	08515	111	4	4	10	08	05	3	05	3	42	56	34	38	57	185	14	20	06
181	24322153	10521	316	5	2	11	09	08	4	09	4	52	33	44	54	48	179	19	22	03
182	25322153	12316	211	5	1	09	08	15	2	07	5	52	34	06	56	36	132	30	31	01
183	26322155	13824	319	8	5	09	12	21	9	11	7	82	37	48	52	55	192	40	43	02
184	27321186	09215	110	5	5	10	09	13	7	06	3	58	48	51	41	48	188	16	13	00

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