A COMPARISON OF STRUCTURED AND UNSTRUCTURED MODES OF TEACHING ELEMENTARY SCIENCE PROCESS ACTIVITIES: THE INFLUENCE OF PERSONALITY AND SOCIOECONOMIC STATUS

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ABSTRACT

The study investigated the effects of two learning styles on the acquistion of science processes and on student preference for learning style. The study also investigated possible interactions of certain personality traits (Extraversion, Neuroticism, Dependency) and socio-economic status with the treatments.

Two sets of activities taken from the Elementary Science Curriculum Study (ESCS) course were arranged in a structured and an unstructured learning style and used in the study. The essential difference between these two styles involved the degree of teacher control and direction.

Four grade six classes were selected for the main part of the study. This selection was done on the basis of no previous exposure to a process science course and a suitable range of socioeconomic status scores. All classes experienced both learning styles and were engaged in both sets of activities during the two week period of the experiment.

Personality and socioeconomic status were assessed by means of standard instruments. Student achievement of science processes and preference for learning style were determined by investigator constructed instruments.

The achievement scores were analyzed by multiple linear regression, controlling for the effects of I.Q. and pretest scores. The preference scores were treated by chi-square analysis.

The results indicated a preference for and superior achievement in the structured style. However, caution must be expressed in drawing this conclusion. An interaction of class and treatments for both

achievement and preference occurred, with one class producing superior achievement in and preference for the unstructured mode. It is suggested that this interaction involved a number of factors, some of which were not investigated in this study. The results indicated a significant interaction of neuroticism and treatment with respect to achievement. No other significant interactions of the personality variables or socioeconomic status with the learning styles occurred. It is suggested that the structured style favoring the more neurotic students may be the result of a greater need for teacher control by the students.

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INTRODUCTION

I. BACKGROUND OF THE STUDY

In recent years many elementary science programs have been developed which emphasize the processes of science. The fundamental assumption underlying these courses is that science is much more than a mere collection of facts which must be produced when called upon. Proponents of the process approach maintain that young children must be introduced to the basic skills and competencies of the scientific disciplines if assimilation of scientific information is to be possible. The Commission on Science Education of the American Association for the Advancement of Science (1967) defines these basic skills as: (1) observing (2) communicating (3) predicitng (4) measuring (5) inferring (6) using space-time (7) using mathematical relations and (8) classifying. More advanced skills include: (1) controlling variables (2) experimenting (3) formulating hypotheses (4) interpreting data (5) formulating models and (6) defining operationally. The expectation is that these skills will be transferable to many disciplines and indeed to many aspects of the student's life.

A science teacher may assume a role in which he is an expositor of knowledge. The student's responsibility in the laboratory lies in following of the instructions given by the teacher. At the other extreme, the responsibility is on the student and the teacher assumes the role of a guide to learning. The development of the above skills or competencies requires the students to be actively involved with manipulative materials. In programs emphasizing process science, children are provided with suitable materials and with teacher guidance the basic science concepts and process skills are developed. The complexity of some of these process skills would suggest that substantial teacher direction is needed. However, if one postulates a parallel between the historical development of scientific processes and the psychological growth of the child, it is suggested that these skills might develop naturally if the child is provided with the appropriate experiences. The claim is that knowledge is more valuable if it is discovered by the learner rather than when it is exposited by the teacher. One can, however, argue that involvement in scientific investigations, often labelled 'discovery' might be a 'natural' way of learning process science. If process learning is more effective in a learning environment involving little teacher direction, discovery learning and process learning may be considered equivalent. There is thus a need to determine the degree of guidance or direction which will make the maximum acquistion of these skills possible, producing a learning environment which prevents student frustration and creates excitement in the learning process.

II. THE PROBLEM

At present a process oriented science course The Elementary Science Curriculum Study, Grades 1-6, initiated by Dr. R.K. Crocker in 1970 exists in some of the schools in the province of Newfoundland. This course is taught by various approaches dependent to some extent on the individual teacher. This study used some modified activities taken from this course in an attempt to determine which learning approach (structured or unstructured) was preferred by students and which approach is more effective in the acquisition of scientific processes. In addition, the study investigated possible interactions between certain personality variables (extraversion, neuroticism, and dependency), and socioeconomic status with the treatments to affect achievement in and preference for a structured or an unstructured approach.

Definitions

Structured Approach In this approach the student was given detailed instructions as to how to approach the problem, and how he should manipulate the apparatus in order to help achieve his objective. Questions were posed as the activity progressed so as to focus the student's attention on crucial aspects of the activity. The post-activity discussion was centered around the specified questions, and where the student's questions diverged from those specified, the teacher reoriented the student's discussion.

Unstructured Approach In this approach the student was presented with the purpose of the activity and the necessary apparatus. However, he was not given the method or means of achieving the purpose, nor was he given instructions on how to manipulate the apparatus. The post-activity discussion was completely determined by the students' questions, and any digressions were accepted as an integral part of the activity.

Scientific Processes A series of activities or operations performed by the scientist in his attempt to understand nature. (Welch, 1966).

Crocker (1972) gives the following descriptions of the scientific processes relevant to this study.

1. Quantifying. Comparison of objects or events and with agreed upon standards. Involves use of numbers, measurement, and use of spatial relationships.

2. Inferring. The process of drawing conclusions based only indirectly on observation: the interpretation of observations.

3. Controlling variables. The process of deciding what variables might influence the outcome of a particular experiment and of holding all variables constant except those the investigator wishes to manipulate. The reproducibility of experimental results depends on the ability to control the proper variables.

4. Interpreting data. The technique of getting the most out of data without overgeneralizing and without loss of information inherent in the data. Devices such as graphs, tables, maps, etc. which are useful in communication are also means of interpreting data.

5. Experimenting. The attempt to produce results by deliberately establishing conditions leading to particular observations. Experimenting generally involves a combination of several other processes.

Hypotheses

The main purpose of the study was to explore the effect of structured and unstructured treatments on student achievement of science processes and to investigate the question of which treatment was preferred by the students. Consequently the two major hypotheses of this study were:

Hypothesis 1-A. There is no significant difference between students exposed to a structured or an unstructured learning environment in the attainment of specific science processes.

Hypothesis 1-B. There is no significant difference in student preference for a structured or an unstructured learning environment.

A review of the literature (See Chapter II) shows that students' achievement in and preference for learning style is influence to some degree by personality factors and socioeconomic status. Therefore, it seems reasonable to expect that an interaction of personality and socioeconomic status with the treatment might exist. Therefore, four secondary hypotheses were formulated. They were:

Hypothesis 2-A. There is no significant interaction between the treatments and (1) Extraversion (2) Neuroticism (3) Dependency, when achievement is used as a dependent variable.

Hypothesis 2-B. There is no significant effect on preference for learning style due to the interaction of treatments and (1) Extraversion (2) Neuroticism (3) Dependency.

Hypothesis 3-A. There is no significant interaction between the treatments and socioeconomic status when achievement is used as a dependent variable.

Hypothesis 3-B. There is no significant effect on preference for a learning style due to the interaction of treatments and socioeconomic status.

Limitations of the Study

1. The study was restricted to two intact grade six classes in each of two elementary schools from two different communities. Generalizations had to be based on assumed similarities between sample and population.

2. The process achievement instruments were constructed by the investigators. Validation was done by three teachers teaching the ESCS course and by three science educators. Reliability tests for each

achievement instrument were restricted to one class which had engaged in activities related to the achievement instrument.

3. The study was conducted over a two week period. Such a period may not be long enough to produce any measureable effect. The results might, therefore, have been different if the study were more extensive.

4. The experimental aspect of the study was confined to two elementary schools having grade six classes which did not have exposure to process science in that grade nor in any of the previous grades. The development of process competence is dependent to some extent on a hierarchy of skills. These students lacked exposure to some of the basic skills which would normally be developed on the lower grades. The results, therefore, may have been different if these students had been exposed to some of the more basic skills before attempting to acquire the more complex processes.

III. SIGNIFICANCE OF THE STUDY

The present emphasis on process oriented science dictates the need to determine the most favorable environment conducive to the acquisition of these competencies or skills. The objectives of science teaching have broadened to include the development of certain basic skills that are used by scientists in their study of nature. Proponents of the process approach to learning science suggest that the acquisition of these skills should take place in an environment in which students are allowed to manipulate materials and 'discover' scientific truths for themselves. If we wish the student to 'discover' nature in the way of the

the scientist, should he be given freedom to achieve his goals in the way he desires, or does a young student need substantial direction from the teacher? Arguments are often given to support both views. The most suitable environment for maximum acquisition of process skills may be dependent upon certain characteristics of students. Do students with a particular personality trait or from a particular social class develop science processes more efficiently given a large amount of freedom or restricted freedom? Do these students prefer a learning style where much guidance is given or a one in which they are allowed to pursue their goals in their own way? The study reported here, combined with another study involving the variables of creativity and sex, attempted to determine the most favorable environment for every student to attain these skills.

A review of the literature revealed very few studies which attempted to relate learning style to the learning of science or attempted to determine the interaction of personality and learning style (See Chapter II). In such cases the learning styles and personality variables were different from those investigated here. No attempt has been made to relate learning style and socioeconomic status. In particular, no studies are reported which attempted variations in the style of learning science processes. The present study attempted to fill some of these deficiencies.

CHAPTER II

REVIEW OF RELATED LITERATURE

I. STUDENT ACHIEVEMENT AS A FUNCTION OF A STRUCTURED OR AN UNSTRUCTURED LEARNING STYLE

In surveying the literature related to learning style the investigator found many terms which parallel those used in this study. Such terms as self-directed as opposed to teacher-directed, non-directed as opposed to directed, permissive as opposed to directive and indirect as opposed to direct, identify learning approaches which are somewhat similar to unstructured and structured approaches as defined in this study.

Kline (1971) conducted a study to ascertain whether or not the open-ended ESCP laboratory block on soils could be learned as effectively by self-directed students as by teacher-directed students, and to determine students' attitudes and interest toward learning science through a laboratory-block discovery approach. The block consisted of five open-ended laboratory investigations structured so as to lead the student to a problem by providing a variety of experiences, while leaving the decisions for the solution of the problem in the hands of the student. The sample consisted of 97 junior-high school students, all of whom were enrolled in the Earth Science course and were using the text <u>Investigating The Earth</u> from the <u>Earth Science Curriculum Project</u>. On the first day of the study, all of the students received an introduction to the block, stressing the relationship of the block to the ESCP materials on soils. At this point the students were randomly divided into experimental and control groups. The control group was teacher-directed, in that each concept was introduced by the teacher and possible approaches to problems introduced in the block were discussed. Thereafter, students went into the laboratory to implement the approach which they had chosen as the most appropriate way of solving the problem.

The experimental group received no formal instruction from the instructor after the introduction to the block on the first day. The students were entirely self-directed. At the completion of the block, each student was given a post laboratory test and on the following day each student was asked to complete a ten item questionnaire, which reflected the student's attitudes and interests in learning science through the use of the open-ended, self-directed, discovery approach in contrast to the more conventional teacher-directed methods often used in teaching science. Analysis of covariance of the post laboratory test revealed no significant differences in the attainments on the laboratory tests of self-directed students as compared with teacher-directed students. Analysis of variance employed on the student questionnaire indicated no significant differences in responses between those students in the experimental groups and those in the control groups.

The above study has some similarities to the present study since the learning styles were somewhat similar and Kline was interested in the students' attitude toward these learning modes. However, the teacher-directed group was presented with various approaches from which it was free to choose one, unlike the structured approach here in which only one method of solving the problem was presented to the student. Also, the study was not related to the attainment of process skills.

In Rainey's study (1965) the learning styles were more similar to those used in the present study. He attempted to evaluate the effect on learning high school chemistry of the kinds of laboratory approaches offered by Chemical Bond Approach to chemistry and the Chemical Educational Materials Study course. The CBA laboratory manual does not tell the students the sequence of steps he must go through or the other procedural details to which he must pay attention in order to arrive at a solution to the laboratory problem with which he is confronted. The CHEM Study manual directs the student step by step through rather detailed experiments. The students used in this study were enrolled in four classes of chemistry. One half of each class was randomly assigned to the non-directed laboratory group. When the instructor felt that enough background material had been discussed in a recitation-discussion session involving both groups together, this group went into the laboratory with a problem to solve and no directions as to procedure other than text material and notes from the discussions. One half of each class was randomly assigned to the directed laboratory group. The students of this treatment group waited in the classroom with text assignments to do while the non-directed groups completed their laboratory work. Upon entering the laboratory they picked up laboratory notebooks which outlined in detail what they were to do. Sixteen experiments were performed during the school term. Four tests were administered to each group: The A.C.S. - N.S.T.A. High School Chemistry Test, The Cooperative Chemistry Test, a written laboratory exam and a performance laboratory exam. A three way analysis of variance and covariance was used to determine any differences in groups. A difference significant at 0.05 level was found on the performance laboratory test (pretest showed no significant difference). However, no significant treatment difference was noted on any of the written test, suggesting that the learning of principles and descriptive chemistry was not influenced by the treatments as described in this study.

In the report of these studies no evidence is given to suggest that the effect of the pretest was accounted for by covariance or other procedures, a possible flaw in the analysis.

The exact nature of the laboratory exams is not given. The question of whether these exams were process oriented has not been answered.

The investigator reports that one group was exposed to CHEM Study and one group to CBA. These courses differ on so many dimensions that any results produced could not be attributed to the laboratory approaches alone.

II. THE PROCESS APPROACH TO LEARNING SCIENCE

To enhance a student's comprehension of how scientists work and scientific knowledge evolves, a science curriculum must be provided in which selected concepts and the associated processes of inquiry are integrated (Nay et al. 1971). Such is the philosophy of the advocates of new science curricula emphasizing the processes or skills of science.

Suchman, Klopfer and Cooley were some of the first science educators to make a serious effort to develop within their students the skills or competencies of science. A major attempt, however, came with the development of the program Science - A Process Approach sponsored by the American Association for the Advancement of Science. This organization developed a complete kindergarten through sixth grade science program aimed at the development of the processes of science (See Chapter I). The psychological structure is such that the simple skills are developed in the lower grades with gradual advancement to the more complex skills. Content is deemphasized and is not restructed to one scientific discipline. Several disciplines are used in an attempt to develop skills needed by the student in his pursuit to understand nature. Although the classroom activities are highly structured, the problem of structure has not been considered in evaluation of the program.

The success of this program led to the development of further programs on the Canadian scene and more recently on the provincial scene.

Nay and associates initiated in 1965 a three-year sequence of science courses, <u>The Edmonton Junior High School Process Approach Science Project</u>. The framework for this project was an amalgamation of several features of <u>Science - A Process Approach</u>, Schwab's theory on the structure of the disciplines, their own perceptions of the nature of science, and the realities and tradition of science teaching. This project did not adopt the process inventory of <u>Science - A Process Approach</u>. A thorough search of biographies, autobiographies, original papers, observations of scientists at work, discussions with scientists, and books by science historians and philosophers led to <u>An Inventory of Processes in Scientific Inquiry</u>. Some of the processes of this inventory include (1) developing a "mental model", (2) seeking further evidence, (3) identifying new problems for investigation, and (4) applying the discovered knowledge.

Early in 1970, Crocker initiated <u>The Elementary Science Curriculum Study</u> for use in grades 1-6 in Newfoundland schools. This program subscribes to the main objectives and assumptions of the AAAS program. The expense of purchasing AAAS apparatus kits made the introduction of this program impossible in the schools of Newfoundland. Considering financial constraints, limited teacher education in science and certain premises governing the basic approach to the development of the program (See Crocker, 1972), a comprehensive teaching guide was prepared and construction of apparatus kits commenced. Development and trials of the program have been carried out over a three year period.

Goulding (1972) carried out an evaluation of this program in which he concluded that students exposed to a process-oriented science course do learn the scientific processes better than students who have not taken such a course. Goulding also found that the attitudes of both students and teachers toward this course were mainly positive. Goulding's study was limited however, in that only two classes of grade five and two classes of grade six from one school was represented. The course was also in its early stages of development.

Process oriented courses require active involvement of students with manipulative materials. However, active involvement is not sufficient for learning the skills or competencies of scientists. Nay and associates, 1971, points out that students generally enjoy the "practical work" involved in an investigation but suffer great mental inertia when it comes to processing the data, making appropriate generalizations from them, and integrating those generalizations into the existing conceptual framework. The overcoming of this mental inertia lies partially in the development of proper strategies for process learning. The present study attempts two strategies referred to as structured and unstructured approaches.

III. STUDIES RELATED TO THE INTERACTIVE EFFECTS OF LEARNING STYLE AND STUDENT PERSONALITY

The investigator was interested in personality factors as they interact with the treatments to affect student achievement and preference. Several studies related to these effects are available.

Wispe (1951) attempted to determine the relationship of performance on the final examination to "directive" and permissive" teaching styles. He also investigated the students' preference for the two teaching methods.

Eight sections in an elementary social science course were matched and differentially taught for one semester by eight graduate teaching fellows who had been selected and trained for their natural aptitude in the respective teaching styles. Four of the sections were directive, highly-structured, and subject-matter centered. Four of the sections were permissive, unstructured and student-centered. Continuous interaction observations were made from behind a one-way screen by two observers using an instrument designed to categorize specific aspects of section behavior. At the end of the semester a Thematic Apperception Test type test, a sentence completion test; and a questionnaire were administered to all the sections separately. Three trained persons independently scored these for positive, neutral, and negative attitudes towards college, sections, instructors, other students, and emotions in sections. For one part of the study the objective-final examination was used as the dependent variable, while the Scholastic Aptitude Test, which was one of the bases for sectioning, was used as the independent variable. Results indicate that the directive sections were preferred by most of the students, because they were clearly defined, and for their presumed value in preparing for examination; although the permissive sections were enjoyed more. The directive and the permissive groups showed no significant difference on the objective-final when taken as a whole, but when the two teaching methods were analyzed for their effects on the "better students" and the "poorer students" it was demonstrated that the directive sections were more beneficial to the poorer students.

Wispe does not give a detailed description of the treatments used in his study. If these treatments parallel closely the structured and unstructured styles defined in this study the results probably give some insight into possible results in this study.

Koenig and McKeachie (1965) hypothesized that the highly independent students would prefer learning, perform better, and be more involved in an independent study situation than in a more directed situation. Also they hypothesized that students with high need for affiliation would prefer, perform better, and be more involved in small group discussion than would other students. Finally, they hypothesized that students high n'achievement would do well in independent study. The experimental groups consisted of 124 students who were enrolled in a single lecture section of an elementary psychology course. The class was divided and each student in one half of the class wrote a paper independently, while students in the other half met in small groups. Later in the semester, the experimental procedure was repeated with the groups reversed so that each student participated in both variations of teaching method. All students also met in regular lecture discussion sections. Students were given the following measures of personality: The California Psychological Inventory, Stott's Inventory, Every-day Life (yielding 3 measures of self-reliance) and finally the Thematic Apperception Test (measuring need for achievement). In addition, observers recorded the interaction in the small group discussions. Measures of the students' preferences, involvement, and performance were administered after each variation of teaching and at the end of the semester. Analysis of the data refuted the first two hypotheses. Measures of self-reliance or of affliation were not related to satisfaction, performance, or involvement in the experimental groups. However, high n-achievement women preferred the independent study and small group discussions while middle achievement women preferred the lecture method. No significant difference was obtained for men. Additional findings were that high n-power women participated less in small groups than low n-power women; whereas the direction of the relationship was reversed for men. Similarly, the non-authoritarian women participated more in the small groups, while the non-authoritarian men were less likely to participate in the permissive discussions.

A possible significant limitation of this study was in the instruments used. Koenig and McKeachie report that the students 'indicated' which method they preferred and how involved they were in that portion of the course. The nature and reliabilities of these instruments have not been reported. The performance measure was taken as the students' performance in the small groups and on the paper.

In Beach's study the personality variables were the same as two of those in the present study although the learning styles were quite different. Beach attempted to relate academic achievement in varying learning situations in an advanced educational psychology course to the personality trait of sociability (or social introversion-extraversion).

The sample consisted of the students in an advanced educational psychology course at the University of Michigan in the fall of 1956-57. Following preliminary testing on course achievement and personality variables, the students were randomly distributed into four experimental groups on a predetermined proportional basis. These groups were characterized by varying degrees of student interaction and student-teacher contact: A (a lecture section), B (an interactive discussion class), C (a group of small instructorless groups of five members each), and D (an independent study group). At the end of the semester the same achievement test was given. Achievement in the course was measured in terms of gain in scores on the post test over the score earned on pretest. The chi-square test of significane (one-tailed) was applied for each group.

In the lecture section a difference in achievement was found in favor of the less sociable student. In the instructorless groups a significant difference was found favoring the more sociable student. Less sociable students in the interactive discussion class achieved better than the sociable students, a result opposite to that predicted. No differences in achievement were found between the more or less sociable students under conditions of completely independent study.

Amidon and Flander's study (1961) made use of an attempt to measure dependence in students. The teaching style differed, however, from the present study.

Amidon and Flanders attempted to determine the effects of direct vs. indirect teachers behavior and of clear vs. unclear student perception of learning goal on the achievement of eight grade geometry students. The sample consisted of 140 eight grade dependent prone pupils from a larger population of 560 students. All students were randomly assigned to one of the following experimental treatments: direct teacher influence with clear goals, direct teacher influence with unclear goals, indirect teacher influence with unclear goals. A pretest of geometry achievement and a test of dependence-proneness (developed by Amidon and Flanders, 1960) were administered. A tape-recording was played introducing the basic concepts of the lesson. In half of the groups the immediate goals were made clear and in half the goals were made less clear. In the direct treatments a teacher gave a 15-minute lecture, with a few questions explaining the material and illustrating problems that could be solved. In the indirect treatments, a teacher conducted a 15 minute discussion explaining the material and illustrating problems that could be solved. The content coverage was the same in the contrasting treatments. The students then had about 15 minutes to practice solving problems at their seats by working on a problem sheet. The posttest of achievement was administered. The entire sequence lasted 2 hours. Students in the various classifications were then compared on the basis of pre and post achievement tests in geometry. Analysis showed no differences between the clear goal and unclear goal treatments, indicating that in this study, at least, achievement of dependent-prone students was not affected by perception of the learning goal. An analysis of the direct and indirect treatments indicated that children taught by the indirect teacher learned more than did the children taught by the direct teacher.

Amidon and Flanders did not investigate possible interactions of student personality and learning styles in this study. However, in a previous study (1960) they found that dependent-prone students were more sensitive to the directive aspects of the teacher's behavior. As the teacher becomes more directive, this type of student finds increased satisfaction in more compliance. Such information would possibly suggest that dependent-prone students would favor the structured style in the present study.

A possible drawback of the study conducted by Amidon and Flanders is the very limited time. Such a limitation leads one to question the generalizability of the findings.

Tuckman (1969) conducted a study in which he examined students' satisfaction with their courses, preference for their teachers, and course grades as a joint function of the style of their teachers and their own personalities. Teaching style was examined using the directive-nondirective dimension. Student personalities were classified as either abstract-independent or concrete-dependent. The sample used in the study was made up of 344 male students, all of whom were in the eleventh or twelfth grade of a vocational-technical high school. Each of these students provided data about a teacher of a non-vocational subject (eg. English) while about half also provided data about a teacher of a vocational subject (eg. carpentry). Students first completed the Student Perception of Teacher Style scale developed by Tuckman in order to classify the extent to which a teacher was directive or nondirective. Students in the classes of these teachers then completed the Interpersonal Topical Inventory developed by Tuckman - a forced-choice measure of the abstract-independent and concrete-dependent personality types, and the California Short Form of the F Scale - a measure of authoritarianism. At the conclusion of the school year, students of the 24 teachers completed two scales, one of which was a measure of course satisfaction and the other a measure of teacher preference. Finally, course grades on participating students were obtained from final teacher reports. Data from vocational and non-vocational teachers were analyzed separately. Two-way analysis of variance were undertaken for each of the three dependent measures: course satisfaction, teacher preference, and course grades. Moreover, separate analyses were undertaken using the Interpersonal Topical Inventory personality measures and the F scale. Thus, 12 analyses were performed. Results showed a significant interaction in which abstract-independent students preferred nondirective over directive teachers, while concrete-dependent students did not differentiate between teacher styles. It was also shown that the students obtained significantly higher grades in non-vocational subjects from non-directive than from directive teachers. In vocational subjects no differences appeared.

The results of this study support the findings of Amidon and Flanders. Both studies concluded that students achieve better in an atmosphere where less direction is given by the teacher. However, Tuckman's study, a little broader in scope, considers student preference for teachers.

Brown (1967) investigated the effects of certain teaching styles (inquiry and expository) and personality trait (attitude toward authority) on cognitive achievement. Two levels of achievement were assessed, representing the knowledge category and the Higher Cognitive skills of the Taxonomy of Educational Objectives, and based on the course of study for grade seven science.

Nine teachers were selected for their use of an inquiry approach or an expository approach as their basic mode of teaching. Analysis of verbal interaction in their classes indicated that anticipated differences between inquiry and expository teaching did exist between the two groups of teachers.

The personality trait was assessed by means of an attitude schedule, developed for this study, which identified four personality types: the stereopath, the non-stereopath, the negativist and the acquiscent. A total of 407 pupils were involved.

The data were analyzed by multiple linear regression, adjusting final achievement scores for pretest scores. The other variables used in the analysis were the I.Q. score, sex, style of teaching and personality type of the pupil.

Each of the variables was found to contribute significantly to the prediction of achievement, but no evidence of interaction effects among them was found. Boys scored higher than girls in both levels of achievement. Differences among the four personality types followed the same pattern in both levels of achievement, but were significant in the knowledge level only.

For the styles of teaching, all differences were in favor of the expository mode. However, when the skills scores were adjusted for knowledge posttest scores, which may be a more appropriate comparison, the differences were not significant.

IV. STUDIES RELATED TO STUDENT ACHIEVEMENT AS A FUNCTION OF DEGREE OF EXTRAVERSION AND NEUROTICISM

This study investigated possible interactions between certain personality variables and socioeconomic status with the treatments. However, a review of studies relating achievement generally to these personality variables and socioeconomic status is justified on the grounds that such information may help explain any interactions that may exist in the present study. However, since these studies relate only peripherally to the present one very little discussion is given.

Many investigations have been made into the relationship of educational achievement and the degree of extraversion and neuroticism. Some of this work is based on a theory of personality expressed by Eysenck (1953), which proposes that there are dimensions of personality almost independent of each other, that is, extraversion-introversion (E and I), neuroticism-stability (N), psychoticism, and Intelligence (I.Q.). In addition, Eysenck (1957) has put forward postulates about the extravert and introvert which can be interpreted to bear directly on their possible output in scholastic work. Briefly, the postulates state that (a) human beings differ in the speed and strength with which excitation and inhibition is dissipated, and (b) individuals in whom excitatory potential is generated slowly and is relatively weak and in whom reactive inhibition is developed quickly and strongly, but dissipated slowly are thereby predisposed to introverted patterns of bahavior. Extraverts follow the exact opposite of this pattern.

Studies attempting to connect educational achievement and the degree of extraversion and introversion show conflicting results. Many studies report that neuroticism is positively connected with academic achievement and yet a large number report the contrary. However, when restricted to work with children most evidence tends to support the hypothesis that stability, as opposed to neuroticism, is positively related to educational achievement. With respect to the relationship between introversion-extraversion and academic achievement most studies with children show a significant connection between extraversion and academic achievement.

Child (1964) and Finlayson (1970) report high achievement with the stable introvert, Rushton (1966) reports high achievement with the stable extravert for girls and the stable introvert for boys and Entwistle and Entwistle (1970) reports high achievement with introverts but reports no relationship of attainment and neuroticism.

Several reasons are offered for such a diversity of results:

(a) The effects of extraversion-introversion, and neuroticism stability on academic attainment may be different at different ages. (Rushton, 1966 and Entwistle and Entwistle, 1970)

(b) The effects vary depending on the criteria used. Lynn (1957) found that neuroticism had a different effect according as the criterion was school work in English or in arithmetic.

(c) Sex differences. Entwistle and Cunningham (1958) found that attainment was highest in girls for the stable extravert. For boys attainment was highest in the stable introvert.

V. STUDIES RELATED TO STUDENT ACHIEVEMENT AS A FUNCTION OF SOCIOECONOMIC STATUS

The studies reviewed in the previous section viewed the individual as an isolated unit. The studies below consider socioeconomic status as a sociological determinant of student achievement. These studies again are of minor interest and only mention is made.

Numerous studies are available attempting to relate socio-economic status with academic achievement. Most of these studies work with young children. Gibboney (1959), Giammatteo (1967) and Peck (1971) support the hypothesis that higher achievement is associated with higher socioeconomic status.

Davis and Frederiksen (1955) refuted this hypothesis. However, their sample consisted of university graduating students. They found that public school graduates were superior academically to private school graduates during the freshman year and that this superiority was maintained during the sophomore year, even though the two groups did not differ with regard to ability.

Davis and Frederiksen offer a possible explanation for their findings. Since the public school graduates are from somewhat lower socioeconomic status, college is an important means of enhancing status; private school graduates, on the other hand, need only to maintain their status level. For the latter group, therefore, simply graduating from college may be more important than the academic record they establish. This negative motivational factor is not present in school children of an earlier age and thus high academic achievement in children of high socioeconomic status is due to other factors.

SUMMARY

Reported studies show conflicting results as to the effect of learning style (highly directed as opposed to little or no direction) on science learning. Kline found no significant differences in achievement in a teacher-directed environment and a student-directed environment. Rainey, however, found significant differences between a directed environment and a nondirected environment on a performance laboratory exam but not on a written laboratory exam. In Kline's study no difference in preference for styles was found, while Wispe and Brown found a preference for a directive learning environment. A thorough search of literature did not reveal any studies which were specific to the learning of science processes.

Several studies are available which attempt to look at interactions of learning style and student personality. Evidence tends to support the contention that a highly directed (structured) learning style benefits the lower ability, introverted, and dependent students more than a style in which the teacher plays a submissive role. However, in such studies where the criterion was achievement the process dimension of science was neglected. Studies, if any, related learning style and students' socioeconomic status have not been reported.

Studies relating educational achievement to personality variables and socioeconomic status, peripherally related to the study, show diversified results. This diversity seems to relate to differences in age and sex of objects and academic discipline tested.

CHAPTER III

THE DESIGN OF THE STUDY

This chpater contains a description of the instruments and procedures used in this study. The study investigated (1) achievement of science processes in a structured and an unstructured learning environment, (2) student preference for learning style, (3) possible interactions between certain personality variables and socioeconomic status and the learning styles.

I. SAMPLE USED IN THE STUDY

The sample used in the study consisted of two grade six classes from Twillingate Central Elementary School, Twillingate, Nfld. and two grade six classes from St. Joseph's Elementary School, Windsor, Nfld. Two constraints influencing the selection of schools involved were: (1) since the investigator was interested in the student's socioeconomic status as it interacts with the treatments, the communities selected needed to contain a wide range of father's occupations, the criterion used to determine the socioeconomic ranking of the students, (2) since the study was conducted late in the school year it was important to have classes that did not have the ESCS course during the year, otherwise some of the activities carried out would be duplicated in the study. Schools selected did not have the ESCS course in grade six, nor in any previous grades. The two classes selected from St. Joseph's Elementary were grouped heterogeneously. The classes from Twillingate Central Elementary were grouped homogeneously according to past academic performance. Random selection was not possible due to the school setting.

II. PROCEDURES

This study was carried out as part of a broader study in which the effects of a number of other independent variables were investigated. This arrangement allowed two investigators to work as a team in the construction of instruments and conduct of the experiment.

The investigators first selected from the ESCS course five sequential activities on balancing and five sequential activities on density-volume. Each activity was arranged in a structured and an unstructured style as defined in Chapter I.

Pilot Study

The pilot study served two functions: (1) to determine what problems would be encountered while the students were engaged in the activities, and (2) to determine the reliabilities of the achievement tests and the test of preference for the learning style.

Two classes of grade six students were selected from Dawson Elementary School, St. John's. The pilot study was conducted over a two week period. One class engaged in a set of activities related to balancing in an unstructured learning style. The other class engaged in a set of activities related to density-volume in a structured learning style. The investigators noted any difficulties experienced by students. These difficulties were only minor and the necessary changes were made prior to the major study.

When the activities were completed each class was given the process achievement test related to the activities they did during the two week period. In addition, a semantic differential was administered in an attempt to determine the students' attitude toward the style of learning during that period. After two weeks the process achievement tests and the semantic differentials were again administered. The calculated reliabilities of the semantic differentials were low due to the lack of a differential response for styles combined with highly favorable responses for both styles. This necessitated a revision of this instrument. The reliabilities of the achievement tests were of suitable magnitude and these tests were used in the major part of the study.

Operational Procedure

The Junior Eysenck Personality Inventory, and The Dependence Proneness Scale were administered to the classes selected at Windsor and Twillingate prior to conducting the experiment. The occupations of the students' fathers were obtained at the same time.

During the course of the experiment one investigator worked with two classes at St. Joseph's Elementary School, Windsor and the other investigator worked with two classes at Twillingate Central Elementary School, Twillingate. For both learning styles the activities were process based and were carried out by students working in pairs. During the structured learning style, students were presented with a detailed instruction sheet designed to orient the students toward a predetermined goal. The teachers moved freely among the students during the course of the activities and posed questions on significant aspect of the activity.

If the students diverged from the instruction sheet, the teacher attempted to reorient the students. During the post-activity discussion, the teacher posed questions and the students asked questions. However, in the discussion the teacher attempted to direct the students to reaching the right conclusions.

During the unstructured learning style, students were given the purpose of the activity, and the necessary apparatus. However, they were not given instructions on how to achieve the objective. The teacher moved freely among the students during the course of the activities but posed no questions to the students. Any divergence from the specific goals was not prevented. During the post-activity discussion the teacher asked no questions but attempted to answer the students' questions irrespective of their relevance to the original objective.

Prior to and following each set of activities each class was given the science process achievement test related to the activities of the week. Each class experienced both learning styles and both sets of activities as shown in Table I. It is noted that the design was such that the order of presentation of activity, time and learning style were counterbalanced.

At the end of each week a semantic differential related to the learning style of the week was given to each class to determine the student's attitude to that particular style of learning. Each semantic differential required approximately 10 minutes to administer. It was intended to determine the students' preference for learning style by considering attitude score differences. However, the lack of a differential response for styles combined with highly favorable responses for both styles made this instrument inadequate for use

TABLE I

SUMMARY OF SEQUENCE OF PRETESTS, TREATMENTS, POSTTESTS AND PREFERENCE INSTRUMENT

	WEEK 1			WEEK 11			
CLASS	PRETEST	MODE TOPIC	POSTTEST	PRETEST	MODE TOPIC	POSTTEST	
1	Balancing	Structured Balancing	Balancing	Density	Unstructured Density	Density	Preference Instrument
2	Density	Unstructured Density	Density	Balancing	Structured Balancing	Balancing	Preference Instrument
3	Balancing	Unstructured Balancing	Balancing	Density	Structured Density	Density	Preference Instrument
4	Density	Structured Density	Density	Balancing	Unstructured Balancing	Balancing	Preference Instrument

in the study. Consequently, a modification of this instrument had to be undertaken and administered two weeks following the termination of the activities.

III. TESTING INSTRUMENTS

I. The Junior Eysenck Personality Inventory

This inventory was designed to measure the two major personality variables of neuroticism or emotionality, and extraversion-introversion in children. The 60 item scale is an extension of the Mauslsey Personality Inventory and the Eysenck Personality Inventory. (Manual for the Junior Eysenck Personality Inventory, 1963)

Split-half as well as test-retest reliability coefficients have been found. The reliabilities average between 0.7 and 0.8. Reliability tends to increase with age for extraversion, somewhat less so for neuroticism.

Very little is known about the validity of the Junior Eysenck Personality Inventory. However, in one study two hundred and twenty-nine children, guidance clinic subjects, were tested and rated with respect to the extraverted or introverted nature of their symptoms, and it was found that the group as a whole was very significantly above the standardization group with respect to neuroticism, and that there was a very significant difference with respect to extraversion between children showing extraverted symptoms and those showing introverted symptoms.

2. The Dependence Proneness Scale

This scale was developed by Flanders, Anderson and Amidon (1961) and includes items that describe students who are complying to adults and conforming to group pressures. Item analysis on an initial 150 item battery resulted in the 45 item scale used in this study.

The reported reliability of the 45 item scale is 0.68; the estimated standard error of measurement is 2.93 for a single score.

Since the scale had not been used locally prior to this study, the 45 item scale was administered on two occasions spaced about 10 days to a grade seven class at McDonald Drive Junior High School, St. John's. The means, standard deviations for boys and girls and the test-retest correlation coefficient are given in Table II. The lower mean and higher standard deviation of the boys are consistent with our cultural expectancy of greater male independence and variability. Considering the small sample and the elapsed time between first and second administrations the results are in reasonable agreement with those reported.

3. A Socioeconomic Index for Occupations in Canada

The Socioeconomic Index for Occupations in Canada, developed by Blishen (1967) uses a simple function of the distribution of education and income to rank 320 occupations in Canada. The scores were determined from the percentage of males in each occupation whose income was reported to be $5,000 or over during the preceeding 12 month period and the percentage who had attended at least the fourth year of high school. The scores range from 76.69 for Chemical Engineers to 25.36 for Trappers and Hunters.

TABLE II

MEAN, STANDARD DEVIATION AND RELIABILITY OF THE DEPENDENCE PRONENESS SCALE

BOYS		GIRLS		
MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	CORRELATION COEFFICIENT (TEST-RETEST)
25.5	4.3	29.7	4.2	0.91

The validity of this instrument has been supported by correlating scores with the Pineo-Porter scores which uses the average evaluation made of an occupational title by a national sample to establish its social standing.

4. Achievement Tests of Science Processes

Two tests, one encompassing activities related to balancing and the other density-volume, were constructed by the investigators. Items were constructed which attempted to test the processes emphasized in the activities. Each test consisted of 15 items which were expected to be completed in approximately 20 minutes. In the achievement test related to density-volume the items were multiple choice, while the nature of the items on balancing dictated the need for a varied response on this achievement test.

In the construction of these items the AAAS Competency Measures and Goulding's (1972) tests of science processes served as guidelines. Goulding, however, found that many of the items he used were too difficult for the students tested. There was some indication that the reading level of some of these items was beyond that of the students. Consequently, in order to partially alleviate this problem a validation procedure involving grade six teachers was used. In this validation procedure (Tannenbaum, 1971) the tests were submitted to six validators, three of whom are science educators and three involved with teaching the ESCS course at the grade six level. The validators met the following criteria:

1. Taught children at the elementary school or prepared teachers to teach at that level.

2. Were recommended by at least one of the science educators in the Department of Curriculum and Instruction.

Either or both of:

3. Had published or done research in science education.

4. Had worked with a curriculum project.

Each validator was asked to scale each item in terms of clarity, appropriateness in light of process tested and difficulty with regard to age level. Items with an average of less than 2.5 on a 5 point scale were revised or removed from the test.

The reliability was determined at the end of the pilot study by a test-retest method. Table III shows the mean, standard deviation and reliability coefficient of the two process achievement tests.

5. The Preference Instrument

Osgood (1967) served as a reference in the construction of two semantic differentials designed to measure students' attitude toward a structured and an unstructured learning style. "Learning with many Instructions" and "Learning with few Instructions" were the concepts used. The same bipolar adjectival scales were used for both and an attempt was made to include scales high on the evaluative component with neglible loadings on other factors. It was intended to determine a difference score which would indicate the students' preference for learning style.

In order to determine the reliability of semantic differentials the instrument appropriate to the learning style was administered on two occasions spaced about two weeks to each of the grade six classes used in the pilot study. Results indicated a favorable attitude

TABLE III

MEANS, STANDARD DEVIATIONS AND RELIABILITIES OF THE PROCESS ACHIEVEMENT TESTS.

	FIRST ADMINISTRATION		SECOND ADMINISTRATION		
	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	CORRELATION COEFFICIENT (TEST-RETEST)
Process Achievement (Balancing)	8.0	2.5	7.7	2.9	0.76
Process Achievement (Density-Volume)	9.2	2.8	8.3	2.4	0.70

toward both learning styles suggesting a possible Hawthorne effect. To determine the reliability of each instrument the Pearson-r technique was used to calculate the reliability of each student's responses and the net reliability coefficients were obtained. The reliability coefficients were found to be essentially zero. The unreliability reported was, however, related more to the technique used for computation than to the instrument.

The highly positive responses for both semantic differentials lead to the decision to modify this instrument in a way which would force students to indicate a preference for learning style. Ten questions were constructed which used those adjectives originally found in the sematic differentials. In each case the student was required to indicate the set of activities which best answered the questions. The responses were then scored on eleven point scale, 0-3 indicating preference for density-volume, 4-6 indicating no preference, 7-10 indicating preference for balancing. The scores were than catogorized in such a way to indicate preference for learning style rather than type of activity.

Since the construction of this instrument was post facto, no validity or reliability determinations were carried out.

IV. STATISTICAL DESIGN

The investigator wished to determine which learning style, if either, resulted in a significantly greater achievement of science processes. Also, any interaction of personality and socioeconomic status with learning style as it affected achievement was of interest.

To determine if such main effects and interactions existed the investigator used multiple linear regression in a procedure equivalent to two way analyses of variance with I.Q. and pretest scores as covariates.

This technique uses a linear weighted combination of the independent variables to predict a criterion. The weights are calculated in such a way as to make error sums of squares a minimum. The goodness of prediction of the regression equation is given by a multiple correlation coefficient (R). The squared multiple correlation (R^2) represents the amount of variance accounted for by this equation. To determine if a variable contributes to the predictability of the criterion two models are constructed, one (referred to as a full model) which includes the predictor variable under investigation and one (referred to as a restricted model) excluding this predictor. To test the significance of the contribution of this variable to the predictability of the criterion an F ratio is determined. If the probability of getting an F value is greater than or equal to alpha (where alpha is generally chosen in advance to be 0.05 or 0.01), the addition of this variable does not add significantly to the predictability of the criterion. A full description of this technique can be found in Flathman (1968) and Kelly, Beggs, and McNeil (1969).

The nature of the study required ~~the~~ construction of two achievement tests. Standardization was carried out over both tests, that is, both tests were treated as being equivalent. The problem of tests' differences was thus not accounted for. Analysis of data with respect to these tests indicated that sufficient similarity made the standardization procedure used satisfactory. If, however, each test had been standardized individually, a possible interaction of type of activity and treatment to affect achievement may have shown up.

The experiment was partially designed to determine if a preference esists for a structured or an unstructured learning style. A determination of interactions of personality and socioeconomic status with the treatments to affect student preference was also carried out. The preference instrument indicated, for each student, preference for the structured learning style, no preference, or preference for the unstructured learning style. A preference frequency tabulation of preference for the structured and unstructured learning styles and no preference was taken and this was cross tabulated by the variables of interest. The chi-square statistic was than used to compare the observed results with those expected on the stated hypotheses. For each category, observed and expected frequency tabulations were determined. From this information the chi-square value was calculated. This value indicated the goodness of fit between the observed and expected results. From the chi-square value the probability of the result occurring by chance could be found from an appropriate table. A significant deviation between the observed and expected tabulations indicated that the results are due to some factor other than chance.

The idea of independence using the chi-sqaure statistic is equivalent to a lack of interaction using multiple linear regression. That is, a given chi-square value with an associated probability less than the 0.05 significance level indicated the results were not due to chance and the variables are not independent. For a more extensive discussion of the chi-square statistic refer to McNemar (1969) and Garrett (1966).

CHAPTER IV

ANALYSIS OF DATA

The presentation and discussion of the results will be given in two sections. Section A will deal with the main effect of learning style on achievement (hypothesis 1-A) and possible interactions of the independent variables with the learning styles to affect achievement (hypotheses 2-A-1, 2-A-2, 2-A-3, 3-A). Section B will deal with the main effect of learning style on preference (hypothesis 1-B) and possible interactions of the independent variables with the learning styles to affect preference (hypotheses 2-B-1, 2-B-2, 2-B-3, 3-B).

SECTION A

Table IV gives the intercorrelations between the independent and dependent variables under investigation in the study. Correlations between independent variables were low and justified investigating these variables independently. Table V gives the average I.Q. for each class investigated in the study. The tables related to achievement scores are of two basic designs and a discussion of the design of one table from each will suffice.

Tables VI gives the posttest means and standard deviation for each group for both the structured and the unstructured learning styles. Also presented in this table are the means for each group irrespective of learning style.

TABLE IV

INTERCORRELATIONS BETWEEN VARIABLES

	EXTRAVERSION	NEUROTICISM	DEPENDENCY	SOCIOECONOMIC STATUS	I.Q.	PRETEST SCORES
NEUROTICISM	-0.13					
DEPENDENCY	-0.01	-0.13				
SOCIOECONOMIC STATUS	0.30	0.19	0.11			
I.Q.	0.30	-0.14	0.28	-0.10		
Pretest Scores	0.09	-0.02	0.04	-0.11	0.32	
Posttest Scores	0.17	-0.04	-0.01	-0.01	0.41	0.45

TABLE V

MEAN I.Q. FOR EACH CLASS

CLASS	I.Q
1	91
2	107
3	91
4	87

TABLE VI

MEANS AND STANDARD DEVIATIONS OF ACHIEVEMENT SCORES FOR LEARNING STYLE, CLASS, TYPE OF ACTIVITY, TIME, AND I.Q. LEVELS

VARIABLE INVESTIGATED	CATEGORY	STRUCTURED $\bar{X}$	STRUCTURED S.D.	UNSTRUCTURED $\bar{X}$	UNSTRUCTURED S.D.	CATEGORY $\bar{X}$
Treatment		8.38	2.29	7.76	2.62	
CLASS	I	8.65	1.93	7.54	2.39	8.11
	II	8.63	2.31	9.88	2.22	9.30
	III	7.40	2.17	6.84	2.21	7.11
	IV	8.91	2.41	6.76	2.32	7.79
TYPE OF ACTIVITY	Balancing	8.68	2.13	6.80	2.26	7.74
	Density	8.13	2.41	8.79	2.57	8.46
TIME	Week I	8.78	2.18	8.33	2.68	8.56
	Week II	8.00	2.34	7.13	2.39	7.57
I.Q.	High	9.80	2.12	9.31	2.63	9.56
	Medium	9.08	2.67	7.63	2.15	7.86
	Low	7.55	2.03	6.38	2.34	6.97

Table VII gives results obtained from a multiple linear regression technique used in an analysis of the posttest scores. The squared multiple correlations (R^2) obtained for the full and the restricted model compared in testing each effect is given. The degrees of freedom (df) for the numerator and denominators of the F ratio, the value of the F ratio and the probability of obtaining this value are also given. The final column indicates whether the F value obtained was significant or not. Probabilities of 0.05 or less were considered to be significant.

The variation of mean I.Q. for each class as shown in Table V and a pretest mean of 7.29 with a standard deviation of 2.18 indicated the need for control of these variables.

I. EFFECTS OF LEARNING STYLE ON ACHIEVEMENT

Results

Hypothesis 1-A. There is no significant difference between students exposed to a structured or an unstructured learning style in the attainment of specific science processes.

Table VII shows an F value (4.48) with an associated probability ($p < 0.05$). This indicated a significant difference in the learning styles with respect to achievement. This hypothesis was thus rejected.

Discussion

The first row of Table VII indicates a significant difference between the learning styles when achievement is used as the criterion. Such results favor the structured learning style. However, such a

TABLE VII

EFFECTS OF LEARNING STYLE, CLASS, TYPE OF ACTIVITY, TIME, AND I.Q. ON ACHIEVEMENT

Predictor	Criterion	Covariates	df num./den.	R^2 Full	R^2 Restr.	F.	Probability	Significance
Style	Posttest scores	I.Q. Pretest scores	1/184	0.3231	0.3066	4.48	0.036	S.
Class*Treatment Interaction	"	"	3/181	0.3606	0.3231	3.54	0.016	S.
Class	"	"	3/184	0.3231	0.2984	2.23	0.086	N.S.
Activity*Treatment Interaction	"	"	1/184	0.3126	0.3096	0.782	0.378	N.S.
Activity	"	"	1/185	0.3044	0.3014	0.796	0.373	N.S.
Time*Treatment Interaction	"	"	1/184	0.3372	0.3320	1.44	0.231	N.S.
Time	"	"	1/185	0.3320	0.3014	8.46	0.004	S.
I.Q.*Treatment Interaction	"	Pretest scores	2/184	0.2979	0.2955	0.317	0.729	N.S.
I.Q.	"	"	2/185	0.2972	0.2180	10.4	0.000	S.

conclusion could not be made without investigating possible interactions of class, type of activity, time, and I.Q. with the treatments. Results of these analyses are also given in Table VII (See Page 45). A significant interaction ($p = 0.016$) between class and treatment exists. Inspection of Table VI (See Page 43) indicates a higher mean for classes I, III and IV in the structured learning style while the mean for class II was higher in the unstructured learning style. The evidence of the interaction is most likely attributable to some characteristic of class II.

This interaction led to a consideration of the factors which might contribute to such an effect. Table I (See Page 30) shows that class II was involved with activities related to density-volume in the unstructured learning style during the first week and with balancing activities in the structured learning style during the second week. Inspection of Table VII (See Page 45) shows no interactions between type of activity, time, I.Q. and the treatments to affect achievement. Thus, these factors do not explain the interaction between class and treatments. Table VIII shows students from the higher level of neuroticism achieving better in the structured learning style and those from the low level of neuroticism achieving better in the unstructured learning style. This resulted in a significant interaction ($p = 0.010$) between neuroticism and treatments to affect achievement as shown in Table IX. However, evidence suggest that randomization in classes exists in the neuroticism distribution and little reason is given to suspect a contribution of this factor to the interaction between class and treatments. It is possible that higher-order interactions exist involving some factors not investigated in this study. Such interactions may account for superior achievement of class II in the unstructured learning style while classes I, III and IV achieving

TABLE VIII

MEAN AND STANDARD DEVIATION OF ACHIEVEMENT SCORES FOR EACH LEVEL OF EXTRAVERSION, NEUROTICISM, AND DEPENDENCY

VARIABLE INVESTIGATED	LEVEL	STRUCTURED $\bar{X}$	STRUCTURED S.D.	UNSTRUCTURED $\bar{X}$	UNSTRUCTURED S.D.	LEVEL $\bar{X}$
EXTRAVERSION	High	9.74	2.34	8.13	3.35	8.94
	Medium	8.57	2.51	7.81	2.47	8.19
	Low	7.37	1.63	7.15	2.03	7.26
NEUROTICISM	High	9.24	2.39	7.50	2.65	8.37
	Medium	8.82	2.57	7.44	2.45	8.13
	Low	7.76	2.05	8.29	2.94	8.03
DEPENDENCY	High	9.26	1.97	8.87	2.19	9.07
	Medium	8.52	2.44	7.48	2.20	8.00
	Low	8.00	2.58	6.96	3.24	7.48

TABLE IX

EFFECTS OF EXTRAVERSION, NEUROTICISM AND DEPENDENCY ON ACHIEVEMENT

Predictor	Criterion	Covariates	df num./den.	R^2 Full	R^2 Restr.	F.	Probability	Significance
Extraversion* Treatment Interaction	Posttest scores	I.Q. Pretest scores	2/135	0.3331	0.3155	1.78	0.172	N.S.
Extraversion	"	"	2/138	0.3103	0.3002	1.00	0.370	N.S.
Neuroticism* Treatment Interaction	"	"	2/135	0.3566	0.3110	4.78	0.010	S.
Neuroticism	"	"	2/138	0.3076	0.3002	0.738	0.480	N.S.
Dependency* Treatment Interaction	"	"	2/135	0.3270	0.3206	0.649	0.524	N.S.
Dependency	"	"	2/138	0.3186	0.3002	1.86	0.159	N.S.

science processes better in the structured learning style. However, it is important to note that although a significant class-treatment interaction exists a significant main effect of treatment is still present.

II. EFFECTS OF PERSONALITY ON ACHIEVEMENT

This section deals with the interaction of personality with learning styles as it affects achievement of science processes.

Results

Hypothesis 2-A-1. There is no significant interaction between the treatments and extraversion when achievement is used as a dependent variable.

The small value of F (1.78)(See Table IX Page 48) indicated that extraversion does not interact with the treatments ($p > 0.05$) to affect achievement. The null hypothesis was thus not rejected.

Hypothesis 2-A-2. There is no significant interaction between the treatments and neuroticism when achievement is used as a dependent variable.

The value of F (4.78)(See Table IX Page 48) was sufficiently large to give a significant interaction ($p < 0.05$). Neuroticism thus interacts with the treatments to affect achievement. The null hypothesis was thus rejected.

Hypothesis 2-A-3. There is no significant interaction between the treatments and dependency when achievement is used as a dependent variable.

An F value (0.649)(See Table IX Page 48) with an associated $p > 0.05$

gave no interaction between dependency and the treatments. The null hypothesis was thus not rejected.

Discussion

The lack of extraversion-treatment and dependency-treatment interactions was contrary to expectation. Evidence suggests (See Chapter II) that the introverted and dependent students achieve better in a lerning environment which is highly teacher directed. Such conclusions could not be reached from the results of this study. However, it should be noted that a null result may well indicate measurement and other errors, rather than the true absence of the expected effect.

The direction of the neuroticism-treatment interaction was such that students high in neuroticism achieved science processes better in the structured learning style and those low in neuroticism achieved science processes better in the unstructured learning style. Such a result could be explained if one considers the possibility that students high in neuroticism have a greater need for security than those low in neuroticism. An environment which provides this needed security would result in higher achievement for the higher neurotic students. In view of the neuroticism-treatment interaction influencing achievement a dependency-treatment interaction was expected with students with a high dependency level achieving better in the structured style. The result of this study did not show this interaction.

III. EFFECTS OF SOCIOECONOMIC STATUS ON ACHIEVEMENT

The study attempted to determine if socioeconomic status interacted with the learning styles to affect achievement. The results are given in Tables X and XI.

Results

Hypothesis 3-A. There is no significant interaction between the treatments and socioeconomic status when achievement is used as a dependent variable.

Table XI shows the F value (1.40) obtained had an associated probability $p > 0.05$. This result indicated that socioeconomic status does not interact with the learning styles to affect achievement. The null hypothesis was thus not rejected.

Discussion

Previous research attempting to relate socioeconomic status and achievement has not concentrated specifically on interaction of teaching style and socioeconomic status. The results of the study indicate that no interaction exists between socioeconomic status and the learning styles used in this study, again noting, of course, that measurement errors, as well as true null effects, lead to null results in a statistical analysis.

SECTION B

The tables related to an analysis of the preference scores are similar and a discussion of only one will be sufficient.

Table XII gives an observed and expected preference frequency tabulation for learning style. The number of students who preferred the

TABLE X

MEANS AND STANDARD DEVIATIONS OF ACHIEVEMENT SCORES

FOR EACH LEVEL OF SOCIOECONOMIC STATUS

VARIABLE INVESTIGATED	LEVEL	STRUCTURED $\overline{X}$	STRUCTURED S.D.	UNSTRUCTURED $\overline{X}$	UNSTRUCTURED S.D.	LEVEL $\overline{X}$
Socioeconomic Status	High	9.25	2.33	7.96	2.30	8.61
	Medium	8.40	2.29	7.88	2.79	8.14
	Low	7.36	1.97	7.24	2.62	7.30

TABLE XI

EFFECT OF SOCIOECONOMIC STATUS ON ACHIEVEMENT

Predictor	Criterion	Covariates	df num./den.	R^2 Full	R^2 Restr.	F.	Probability	Significance
Socioeconomic Status* Treatment Interaction	Posttest scores	I.Q. Pretest scores	2/176	0.3544	0.3442	1.40	0.250	N.S.
Socioeconomic Status	"	"	2/179	0.3389	0.2988	5.42	0.005	S.

TABLE XII

PREFERENCE FOR LEARNING STYLE

STRUCTURED O(E)	NEUTRAL O(E)	UNSTRUCTURED O(E)
52(36)	23(27)	24(36)

$\chi^2 = 12.43$ for 2df, $p < 0.05$, S.

structured learning style, the unstructured learning style and those with no preference are presented with the expected frequencies given in parenthesis. This table also gives the chi-square value for an associated number of degrees of freedom, the probability of obtaining this value and whether or not this chi-square value was significant.

I. EFFECTS OF LEARNING STYLE ON PREFERENCE

Results

Hypothesis 1-B. There is no significant difference in student preference for a structured or an unstructured learning environment.

A chi-square of 12.43 (See Table XII Page 54) with an associated probability ($p < 0.05$) indicated a significant preference for learning style. The null hypothesis was thus rejected.

Discussion

The information given Table XII (Page 54) indicate a significant preference for the structured learning style. However, an examination of Table XIII shows a significant class-treatment interaction for preference. Classes I, III, IV preferred learning in the structured learning style while class II held preference for the unstructured approach. It is interesting to note that the class-treatment interaction for preference is in the same direction as the class-treatment interaction for achievement. Tables XIV and XV do not show an interaction of activity and time with the treatments. However, Table XVI shows significant interaction of intelligence with the treatments to affect preference. This table shows that a larger number

TABLE XIII

CLASS AND PREFERENCE FOR LEARNING STYLE

CLASS	STRUCTURED O(E)	NEUTRAL O(E)	UNSTRUCTURED O(E)
I	18(15)	6(6)	4(7)
II	6(12)	4(6)	14(6)
III	18(11)	3(5)	0(5)
IV	10(14)	10(6)	6(6)

$\chi^2 = 25.2$ for 6 df, $p < 0.05$, S.

TABLE XIV

TYPE OF ACTIVITY AND PREFERENCE FOR LEARNING STYLE

TYPE OF ACTIVITY	STRUCTURED O(E)	UNSTRUCTURED O(E)
Balancing	22(18)	6(9)
Density-volume	27(30)	18(15)

$\chi^2 = 2.83$ for 1df, $p > 0.05$, N.S.

TABLE XV

TIME AND PREFERENCE FOR LEARNING STYLE

TIME	STRUCTURED O(E)	UNSTRUCTURED O(E)
Week I	28(28)	14(13)
Week II	23(22)	10(10)

$\chi^2 = 0.11$ for 1 df, $p > 0.05$, N.S.

TABLE XVI

I.Q. AND PREFERENCE FOR STYLE

I.Q. LEVEL	STRUCTURED O(E)	NEUTRAL O(E)	UNSTRUCTURED O(E)
High	15(14)	1(6)	12(6)
Medium	17(19)	11(8)	9(8)
Low	17(14)	9(6)	1(6)

$\chi^2 = 17.94$ for 4 df, $p < 0.05$, S.

of those students who preferred the unstructured learning style were in the high I.Q. group. In preference for the structured learning style most students were from the medium and low I.Q. groups. From these results one can conclude that the higher I.Q. students preferred the unstructured learning style while those of lower I.Q. preferred the structured learning style. In this study the mean I.Q. for class II was higher (107 as compared with 91, 91, 87) than the mean I.Q. for classes I, III, IV. It is interesting to note that both a class-treatment and an I.Q.-treatment interaction was obtained here while the I.Q.-treatment interaction is not present in the achievement results.

II. EFFECTS OF PERSONALITY ON PREFERENCE FOR LEARNING STYLE

Results

Hypothesis 2-B-1. There is no significant effect on preference for learning style due to the interaction of treatments and extraversion.

The chi-square obtained (1.3) as shown in Table XVII was small in magnitude with a probability greater than 0.05. Such a result indicated no significant interaction of extraversion and preference for styles. The null hypothesis was thus not rejected.

Hypothesis 2-B-2. There is no significant effect on preference for learning style due to the interaction of treatments and neuroticism.

A larger value of chi-square (4.87) as shown in Table XVIII was obtained from this analysis than in the previous one. However, the value was not large enough to give a significant interaction. The null hypothesis was thus not rejected.

Hypothesis 2-B-3. There is no significant effect on preference

TABLE XVII

EXTRAVERSION AND PREFERENCE FOR STYLE

EXTRAVERSION LEVEL	STRUCTURED O(E)	NEUTRAL O(E)	UNSTRUCTURED O(E)
High	15(17)	6(8)	14(9)
Medium	19(19)	11(9)	9(10)
Low	17(14)	9(7)	4(7)

$\chi^2 = 13$ for 4 df, $p > 0.05$, N.S.

TABLE XVIII

NEUROTICISM AND PREFERENCE FOR STYLE

NEUROTICISM LEVEL	STRUCTURED O(E)	NEUTRAL O(E)	UNSTRUCTURED O(E)
High	16(15)	9(7)	5(7)
Medium	19(19)	11(9)	8(9)
Low	16(16)	5(8)	12(8)

$\chi^2 = 4.87$ for 4 df, $p > 0.05$, N.S.

for learning style due to the interaction of treatments and dependency.

Table XIX shows a larger value of chi-square (6.04) than in the two previous cases. However, again, the value was not large enough to give a significant interaction. The null hypothesis was thus not rejected.

Discussion

The results obtained here are contrary to expectation. It was suspected that the extraverted students would find more satisfaction in a learning style in which they were given more freedom than in another with restricted freedom. Likewise, the introverted students were suspected to prefer a restricted learning environment. Such results were not obtained from this study.

In view of the interaction of neuroticism and treatments to affect achievement one would expect an interaction of neuroticism and preference for learning style. Again such results were not obtained.

Amidon and Flanders (1960) obtained a significant interaction of dependence and structured-unstructured learning style with the dependent-prone students favoring the structured learning style. The results of this study did not support this finding.

III. THE EFFECTS OF SOCIOECONOMIC STATUS ON PREFERENCE FOR LEARNING STYLE

Results

Hypothesis 3-B. There is no significant effect on preference for a learning style due to the interaction of treatments and socioeconomic status.

TABLE XIX

DEPENDENCY AND PREFERENCE FOR STYLE

DEPENDENCY LEVEL	STRUCTURED O(E)	NEUTRAL O(E)	UNSTRUCTURED O(E)
High	17(17)	6(8)	12(8)
Medium	18(18)	9(8)	9(8)
Low	15(13)	9(6)	3(6)

$\chi^2 = 6.04$ for 4 df, $p > 0.05$, N.S.

The chi-square value as shown in Table XX obtained from this analysis was 2.01, less than what is required to give a significant interaction at the 0.05 probability level. The null hypothesis was thus not rejected.

SUMMARY

The results indicated a preference for and superior achievement in the structured learning style. However, these conclusions are given with some reservations. In testing the major hypotheses (1-A, 1-B) class-treatment interactions occurred affecting achievement and preference. Class II, with higher mean I.Q. than the other three classes, achieved science processes better and preferred learning in the unstructured style. Analyses of the effects of the other variables in the study did not explain these interactions. It is suspected that the interactions are of a higher-order involving some variables not investigated in this study. However, a significant interaction of I.Q. and the treatments on the preference measure indicated that students from a high I.Q. grouping preferred learning in the unstructured learning style while those from a lower I.Q. preferred a structured environment. Such a result was not obtained on the achievement variable. The class-treatment interaction affecting achievement could thus not be explained on the basis of I.Q. The fact that class II achieved significantly better in the unstructured style may be due, in part, to a previous exposure to a learning approach that is somewhat unstructured. The other classes may, in fact, have greater familiarity with the structured style. No evidence exists to substantiate this.

TABLE XX

SOCIOECONOMIC STATUS AND PREFERENCE FOR STYLE

SOCIOECONOMIC STATUS LEVEL	STRUCTURED O(E)	NEUTRAL O(E)	UNSTRUCTURED O(E)
High	14(12)	6(7)	5(6)
Medium	20(23)	14(12)	11(10)
Low	16(15)	6(8)	7(7)

$\chi^2 = 2.01$ for 4 df, $p > 0.05$, N.S.

The question of whether students preferring a particular learning style achieved significantly better in that style than in the other was not given major consideration. However, analysis carried out indicated that students who preferred a particular learning style did not achieve significantly better in that style than in the style not preferred.

No interactions of extraversion, neuroticism, dependency and socioeconomic status with the treatments to affect student preference for learning style were obtained.

The finding of null results may be due, in part, to the presence of measurement errors. For example, students may not have realized a clear differentiation between learning styles. Certainly the novelty of the treatments makes the preference data somewhat unreliable. This was evident from the first administration of the preference instrument.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

I. SUMMARY

The study was designed to determine which of two teaching approaches produced greater achievement of science processes and which approach was more preferred by students. The study also attempted to determine if interactions existed between certain personality variables and socioeconomic status with the learning styles to affect achievement and preference.

Research Design

Two sets of activities, one related to balancing and another related to density-volume, were taken from The Elementary Science Curriculum Study (ESCS) and modified to reflect a structured and an unstructured learning style. The essential difference between these two styles was the amount of teacher control and direction.

Two grade six classes from each of two schools were selected for the main part of the experiment. These classes were selected on the basis of no previous exposure to process oriented courses and from communities which would give a suitable socioeconomic status range. The classes were administered The Junior Eysenck Personality Inventory and the Dependence Proneness Scale prior to the conduct of the experiment. At the same time the students' socioeconomic status and I.Q. were obtained.

The experiment was conducted over a two week period. Each class experienced both learning styles and engaged in both sets of activities. The design was such that the order of presentation of activity, time and learning style was counterbalanced. At the beginning and end of each week each class was given an achievement test related to the activities of the week. These achievement tests were self-constructed and validated by six educators familar with the process science course. At the end of the two week period a preference instrument was administered to each class.

The achievement scores were analyzed by a multiple linear regression technique, controlling for previous knowledge and the effects of I.Q. The preference scores were treated by chi-square analysis.

Findings

Results from this investigation show that three of the four classes achieved science processes better and preferred learning in the structured learning style. However, one class produced superior achievement in and preferred the unstructured environment. An interaction of class and treatments to affect achievement and preference thus resulted.

There was no significant interaction between I.Q. and treatments to affect achievement. However, a significant interaction of I.Q. and treatments affecting student preference did result. This may account for the interaction between class and treatment to affect preference since the class which preferred the unstructured treatment was also the class of higher average intelligence.

No interactions of extraversion, dependency and socioeconomic status with the treatments to influence achievement or preference were obtained. A significant interaction of neuroticism and the treatments to influence achievement, but not preference, resulted.

II. CONCLUSIONS

From the findings of this study several conclusions are drawn.

1. Students achieved science skills better in and indicated preference for a structured learning style although significant class-treatment interactions exist. Such a result leads one to conclude that a learning environment involving substantial teacher direction and control provides a more conducive atmosphere for the acquisition of process science. Students, generally perform better in and favor a learning style in which less initiative is required for discovery. That is, guided discovery seems to be better than unguided discovery in the attainment of process skills.

2. The stated conclusion is drawn with some qualification. The results of this study indicate that the more intelligent students favor a learning style requiring little guidance although the achievement is irrespective of learning styles. It is possible that the more intelligent student suffers less frustration in an environment in which he has to determine his own path of solution than a one in which he is led to such a solution.

3. An interaction between neuroticism and treatments to affect achievement but not preference existed. Such an interaction showed that the more neurotic student achieved significantly better in the structured learning style. One could speculate that the effect on achievement may be due to the need of the more neurotic students for a learning environment in which the chance of success is greater. A structured learning style would more likely provide this needed success. In view of this finding, a dependency-treatment interaction influencing achievement was expected. Such a result was not obtained.

4. No significant interactions between extraversion, dependency, socioeconomic status and the learning styles were produced in this study.

Results did not show a significant interaction between neuroticism and the learning styles affecting preference. One should not conclude that such interactions do not exist. The present study is limited in the short duration of the experiment. A more extensive study may produce significant results.

5. Achievement of process skills was significantly better in the first week than the second week. Such a result was contrary to expectation. One can speculate that the novelty and thus the interest decrease within the short duration of the experiment resulting in lower achievement in the second week.

6. Students from a higher intelligence level achieved significantly better than students from the lower intelligence level. Such a conclusion supports the accepted view of higher intelligence resulting in superior academic achievement.

7. Students from the higher socioeconomic level achieved significantly better than students from the lower socioeconomic level. Table IV shows a negative correlation (-0.10) between socioeconomic status and intelligence. One can only suggest that some other inherent characteristic of the students from the higher socioeconomic level contributed to superior achievement.

III. IMPLICATIONS FOR FURTHER RESEARCH

From the limitation and results of this investigation a number of recommendation are offered for further research.

1. It is suggested that any further studies in this area provide an extended time for the conduct of the experiment. A two week

experiment does not produce substantial development of process skills.

2. It is recommended that in further studies related to structured and unstructured learning styles an analysis of teacher-student classroom interaction be carried out in a pilot study so as to assure a clear differentiation of learning styles.

3. The development of process skills is hierarchical in nature. The present study, conducted late in the school year, used as the sample students with no previous exposure to process science out of concern for duplication of activities. Further extended research in this area might consider students who have had several years experience with elementary processes of science before attempting the more difficult development skills.

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APPENDIX

BALANCING - STRUCTURED STYLE

Activity I

Purpose: To compare the weights of a book, a pencil and two rocks without a balance.

Materials: For each student:
Various objects such as a book, a pencil, two rocks (of about the same weight).

Instructions: Pick up a book with one hand and a pencil with the other. Which is heavier? ________________
Then put down the pencil and pick up a rock. Which is heavier, the rock or the book? ________________
Now put down the book and pick up the other rock. Can you tell which rock is heavier? ________________

Discussion: The difficulty of telling which of two objects is heavier by subjective means when they weigh about the same. The need for an instrument under these circumstances.

Activity II

Purpose: To make a number of balances.

Materials: For each pair of students:
Materials which students may use to construct balances: 12" rulers, hat pin (5"), soda straws, curtain rods, stiff wire and blocks.

Instructions: Take two of your books and place them about 3 inches apart. Now put a hat pin between the two books such that one end of the pin is on one book and the other end on the other book. Now put your ruler at the 6 inch mark on the pin. Is the ruler balanced? __________ How do you know it is balanced? __________
Now take your ruler and put it on the pin at the 5 inch mark. Is your ruler balanced now? __________
Why? ______________________________
Take the soda straw and pierce the pin through it where you think is the middle of the straw. Place the pin with both ends on your books as before. Do you think the straw is now balanced? __________ Why? ______________________
Take some of the other things you've been given and try to make some balances.

Discussion: 1. Establishment of a balanced condition.
2. A seesaw balance.
3. Use of balance to weigh objects as in activity I.

Activity III

Purpose: To compare the weights of objects using a pegboard balance.

Materials: For each pair of students:
Pegboard balance (assembled and balanced)
Paper clips
Objects to be weighed with string attached.
A piece of wood, a big washer, a rock.

Instructions: Put a paper clip in hole # 8 on the left arm of the pegboard balance and put another clip in hole # 8 on the right arm of the balance. Hang one of the rocks on one of the paper clips and the piece of wood on the other paper clip. Which do you think is heavier, the wood or the rock? ____________
Now move the clip to which the rock is attached to the hole # 7. Which do you think is heavier now? __________
Move the same clip to hole # 4. Which do you think is heavier now? __________
Using this balance it seemed as if the rock was heavier at first but now it seems as if the wood is heavier. This cannot be right. It appears as if distance is important when weights are compared. When the wieghts of objects are compared using this balance they must be at the same distance from the center.
Now put one clip in hole # 7 of the right arm and another clip in hole # 7 of the left arm. Attach the rock to one and the wood to the other. Which is heavier? __________
Remove the rock and attach a big washer. Which is heavier the rock or the washer? __________
Then arrange the rocks, the wood and the washer in order of weight with heaviest first and the lightest last.

Discussion: When comparing the weights of objects using a pegboard balance it is important to have the distance from the center equal.

Activity IV

Purpose: To find out what factors are important when trying to balance the arms of a pegboard balance.

Materials: For each pair of students:
A pegboard balance
Paper clips
Big washers

Instructions: To a paper clip put in the hole # 3 on the right arm of your blance hang three washers. Put three washers on a paper clip and attach it to the left arm, such that the left and right arm balances. Note that this is similar to the last acitivty. What can you say about trying to balance equal number of washers on each arm using a pegboard balance? ______________________
To a paper clip put in hole # 5 on the right arm of your balance hang 3 washers. Put 5 washers on a paper clip and attempt to balance the right arm by putting the clip in a number of holes in the left arm. Where did the clip have to be put in the left arm to balance the right arm containing 3 washers in hole # 5? ______________
To a paper clip put in hole # 1 on the right arm of your balance hang 6 washers. Put 3 washers on a paper clip and attempt to balance the right arm by putting the clip in a number of holes in the left arm. Where did the clip have to be put in the left arm to balance the right arm containing 6 washers in hole # 1? ______________
What therefore, are the two factors or variables that you look at when you are trying to balance the two arms?

Discussion: The need to consider both weight and distance when trying to balance both arms of a pegboard balance.

Activity V

Purpose: To use a pegboard balance to find out if there is any relationship between the weight and distance on the right arm and the weight and distance on the left arm when these arms are balanced. To try some more examples to test this relationship.

Materials: For each pair of students:
Pegboard balance
Big washers
Paper clips

Instructions: Put 4 washers on a paper clip and hang the clip through hole # 4 on the right arm of your pegboard balance. Try to balance the right arm by hanging different numbers of washers to a clip and attaching to the left arm. Complete the following table:

Left Arm		Right Arm	
Hole #	# of washers	Hole #	# of washers
	4	4	4
	8	4	4
	2	4	4
	16	4	4

Remove the clip and washers from the left arm of your balance and just take off the washers from the right arm. Keep the clip in hole # 4 in the right arm of your pegboard balance but this time keep changing the numbers of washers that you are attaching, as indicated in the table below. Each time you change the number of washers on the right arm try to balance this arm by putting 4 washers on a paper clip and hanging it from one of the holes in the left arm.
Complete the following table:

Left Arm		Right Arm	
Hole #	# of washers	Holo #	# of washers
	4	4	1
	4	4	2
	4	4	8
	4	4	6

Look at both tables that you completed.
What relationship can you see between the values of weight (in washers) and length for the right arm and the weight (in washers) and length for the left arm? ____________________

Take your washers and clips and see if your relationship holds in some more cases. Write the relationship which seems to hold in symbols.

<u>Discussion:</u> Reinforce the relationship of balanced conditions. Establishment of the proper symbolic representative.

BALANCING - UNSTRUCTURED STYLE

Activity I

Purpose: To compare the weights of a book, a pencil, and two rocks without a balance.

Materials: For each student:
Various objects such as a book, a pencil, and two rocks (of about the same weight).

Instructions: On your desk you will find the objects listed above. Try to compare the weights of the objects without using a balance.

Activity II

Purpose: To make a number of balances.

Materials: For each pair of students.
Materials which students may use to construct balances: 12" rulers, hat pin (5") soda straws, curtain rods, stiff wire and blocks.

Instructions: On your desk you will find the objects listed above. Try and make as many balances as you can using these objects.

Activity III

Purpose: To compare the weights of objects using a pegboard balance.

Materials: For each pair of students:
Pegboard balance (assembled and balanced)
Paper clips
Objects to be weighed with string attached.
A piece of wood, a big washer, a rock.

Instructions: You are given a pegboard balance and two paper clips which are to be put in the holes of the balance arms on which you are meant to hang the objects listed above.
Use this balance to arrange these objects from the heaviest to the lightest.

Activity IV

Purpose: To find out what factors are important when trying to balance the arms of a pegboard balance.

Materials: For each pair of students:
A pegboard balance
Paper clips
Big washers

Instructions: Using your pegboard balance, paper clips and washers, try to balance the left and right arm of your pegboard balance by putting equal number of washers on each arm. Then try to balance the left and right side with unequal number of washers.

Activity V

Purpose: To use a pegboard balance to find out if there is any relationship between the weight and distance on the right arm and the weight and distance on the left arm when these arms are balanced.
Try some more examples to test this relationship.

Materials: For each pair of students:
Pegboard balance
Big washers
Paper clips

Instructions: Using your pegboard balance, washers and paper clips try to find out if there is any relationship between the weight and length on the right arm and the weight and length of the left arm when these arms are balanced.

ACHIEVEMENT TEST 1 - BALANCING

1. Look carefully at the diagram below

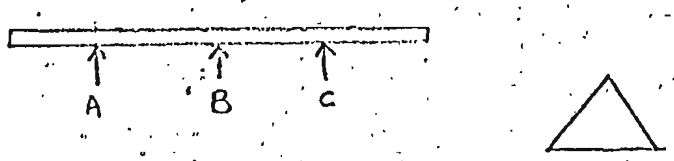
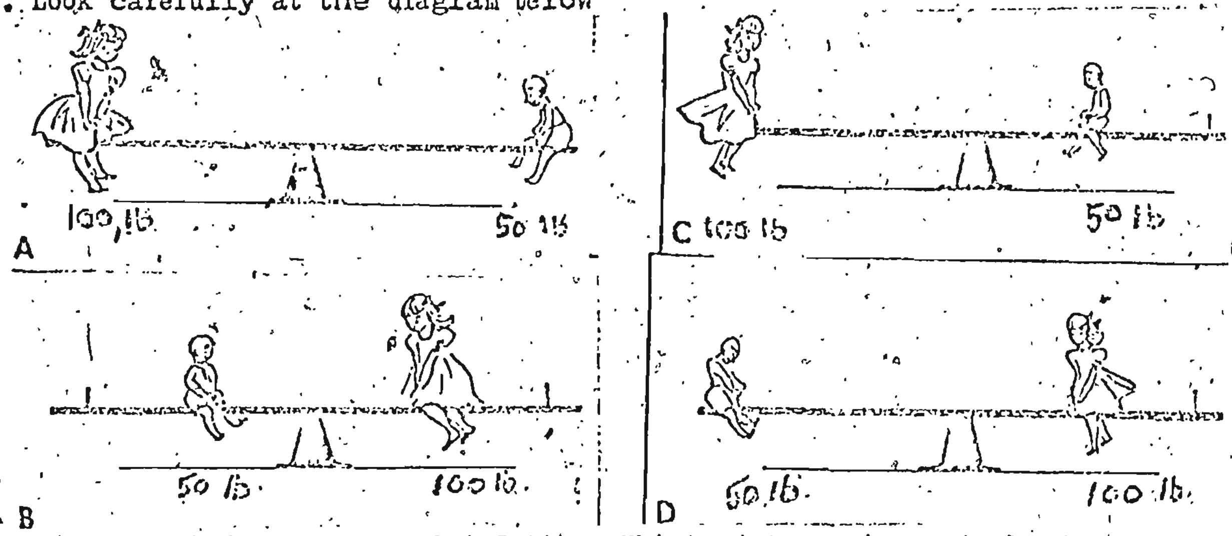


Diagram 1

Diagram 1 shows a stick of the same thickness along. Also shown is a wooden triangle. Check the best position for the block such that the stick would be balanced.

A__________
B__________
C__________

2. Look carefully at the diagram below



George wanted to seesaw with Betty. Which picture shows the best way for Betty who weighed 100 pounds to balance George who weighed 50 pounds? Check the best way.

A__________
B__________
C__________
D__________

3. Look carefully at the diagrams below in which objects are balanced with the same size weights.

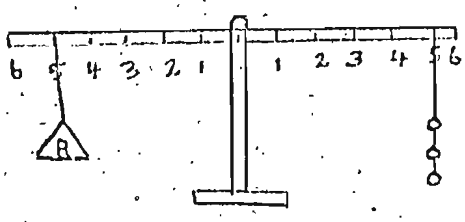


DIAGRAM 3

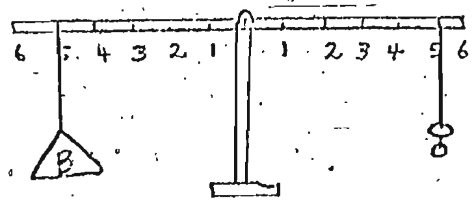


DIAGRAM 4

Check whether you think object A or B is heavier.
Object A ________
Object B ________

4. Look carefully at the diagrams below in which objects are balanced with weights.

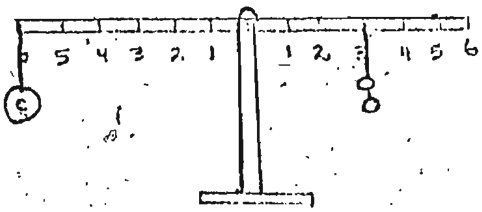


DIAGRAM 5

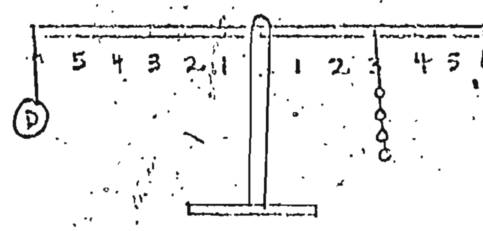


DIAGRAM 6

Check whether you think object C or D is heavier.
Object C ________
Object D ________

5. Look carefully at the diagram below in which two objects are balanced.

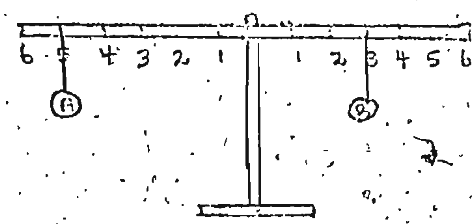


DIAGRAM 7

Underline what you believe to be the right answer.
1. A is heavier than B
2. B is heavier than A
3. A and B have the same weight
4. Cannot tell from information given

6. Look carefully at diagram 8 below. Check whether the arms are balanced or not balanced.

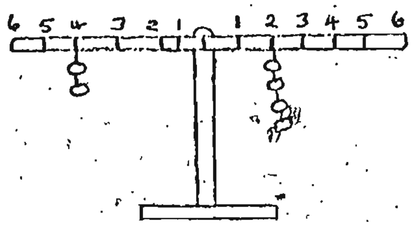


Diagram 8

Balanced ___________
Unbalanced ___________

7. Look carefully at diagram 9 below. Check whether the arms are balanced or not balanced.

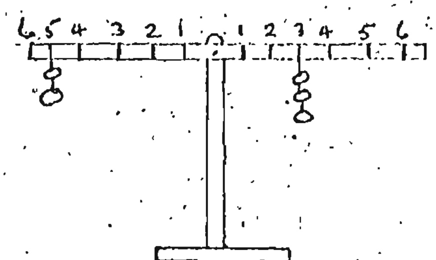


Diagram 9

Balanced ___________
Unbalanced ___________

8. Look carefully at diagram 10 below.

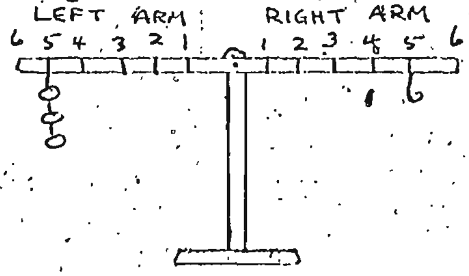


Diagram 10

3 big washers are hooked on a paper clip and put in hole # 5 of the left arm of a pegboard balance. How many big washers on a paper clip in hole # 5 of the right arm are necessary to balance the left?

Put your answer here ____________________

9. Look carefully at the diagram below.

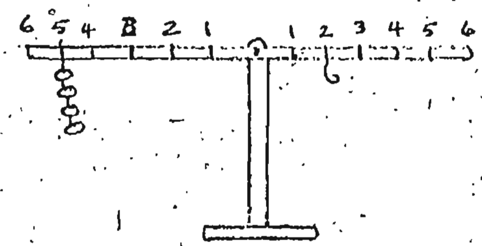


DIAGRAM 11

4 big washers are hooked on a paper clip and put in hole # 5 of the left arm of a pegboard balance. How many big washers on a paper clip put in hole # 2 of the right arm are necessary to balance the left?

Put your answer here ____________________

10. Look carefully at the diagram below.

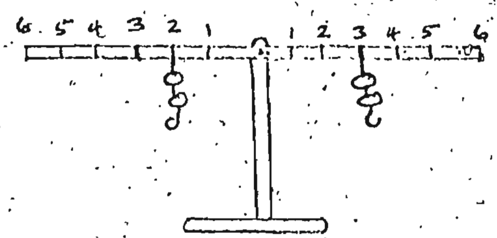


DIAGRAM 12

Where would you hang a single washer in the above diagram in order to balance the left and the right arms? Draw in the single weight in its proper position in the diagram.

11. Refer to the diagram below.

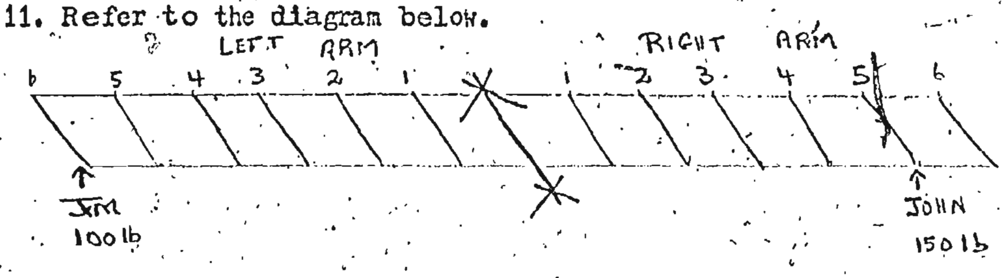


DIAGRAM 13

Jim and John are using a ladder as a seesaw. Jim, who weighs 100 pounds is sitting on bar 6 on the left side of the center. John who weighs 150 pounds is sitting on bar 5 on the right side of the center. The right and left sides are not balanced. To which bar does John have to move to balance Jim on bar 6?

Put your answer here ____________________

12. A student tried to find the relationship between the weights of three objects A, B, and C by using a pegboard balance. Look at the following diagrams and write down what you believe to be this relationship. i.e. which object is heaviest, which object is the lightest and which object has a weight between the other two?

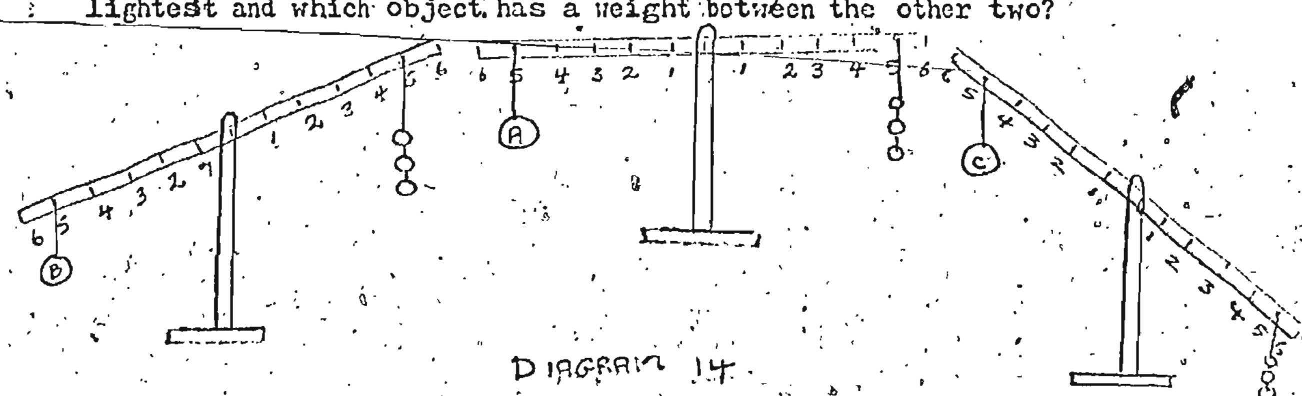


DIAGRAM 14

Put your answer here
Heaviest ________
Next ________
Lightest ________

13. Look carefully at the diagram below.

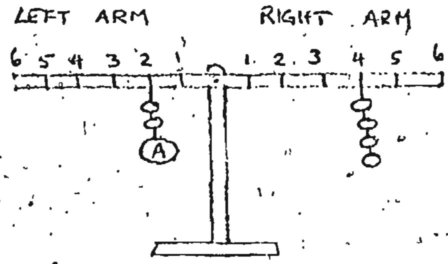


DIAGRAM 15

On the left arm of the balance two washers and object A are hooked in hole # 2. On the right arm 4 washers are hooked in hole # 4. The arms are balanced. What is the weight of object A in units of washers?

Write your answer here ____________________

14. Look carefully at the diagram below.

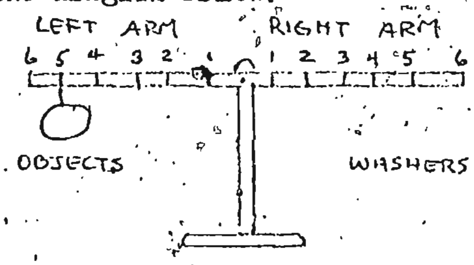


DIAGRAM 16

Two objects are hooked on paper clip and put in hole # 5 of the left arm of a pegboard balance. Washers are hooked on a paper clip and put in holes of the right arm of the balance. The following information is obtained.

Object	Weight in washers	Hole # of Washers
A	1 large washer	5
B	3 small washers	3

Underline what you believe to be correct.

1. A is heavier than B
2. B is heavier than A
3. A and B have the same weight
4. Cannot tell from information given

15. A student tried to determine the relationship between the weights of big and small washers. Refer to the diagrams and table of information to determine this relationship.

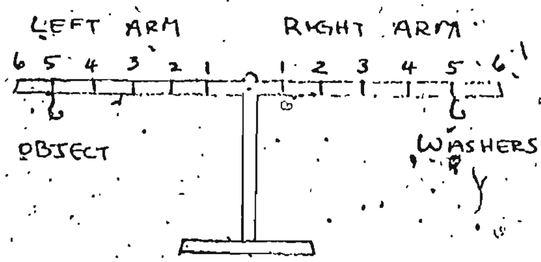


DIAGRAM 17

Left Arm			Right Arm	
Object	Hole #	Large Washers	Small Washers	Hole #
A	5	4	0	5
B	5	0	12	5

The weight of object A = the weight of object B.
Write what you believe to be the relationship between the weight of a large and small washer here.

____

DENSITY-VOLUME - STRUCTURED STYLE

Activity I

Purpose: To describe what happens when liquids are placed into other liquids.

Materials: Each pair of students should have
4 medicine cups of liquid
medicine dropper
styrofoam tray

For the class
paper towels
newspapers

Instructions: Notice that you have 4 medicine cups of different liquids. With your medicine dropper, place a drop of the red liquid into each of the other liquids, and watch to see whether it floats or sinks. Fill in the following table:

Color of liquid	What happens when the red liquid is put in
green	________
clear	________
blue	________

Discussion: 1. When one liquid sinks in another, what does this mean in terms of the relative weights? What does it mean when it floats?
2. If you put liquid A into liquid B and it sinks, what will happen if you put liquid B into liquid A?

Activity II

Purpose: To compare the density of salt and fresh water.

Materials: Each pair of students shaould have
3 medicine cups
medicine dropper
styrofoam tray

For the class
food coloring kit
paper towels
newspapers

Instructions: Take one medicine cup of fresh water and one of salt water, making sure that the same amount of water was in each one. Do you think that there is any difference in the weight of the water in the two medicine cups?
Using your medicine dropper, put one drop of red food coloring into the medicine cup of salt water. DO NOT STIR. Observe what happens. Now put one drop of red food coloring into the cup of fresh water. DO NOT STIR. Did the same thing happen in both cups? What do you think would happen if you put a drop of salt water in some fresh water?
Place a drop of the red-colored salt water into a medicine cup of clear, fresh water. What happens? Is it caused by the salt or the coloring? To find the answer, take another cup and put into it a drop of colored fresh water, what happens?.

Discussion:
1. Does the salt water sink in fresh water?
2. Do equal amounts of salt and fresh water weigh the same?
3. How does the color spread?

Activity III

Purpose: To determine if there is a relationship between weight and density.

Materials: Each pair of students should have.
Medicine cup full of each of the four basic liquids
Styrofoam tray
Medicine dropper

Instructions: Each of the four liquids have been weighed by the teacher and the weights were found to be

Liquid	Number of washers needed
A	3
B	2
C	4
D	1

Using your medicine dropper, place a drop of liquid A into liquid B. Observe whether it sinks or floats. Do the same thing using liquid C and D, and put the results in the table.

Liquid A into liquid B	______
Liquid A into liquid C	______
Liquid A into liquid D	______

Discussion: 1. What does it mean when one liquid floats on another?
2. Why was it necessary to use the same amount of liquid when you weighed them?
3. What is density?

Activity IV

Purpose: To describe what happens to the volum and weight of two objects when they are mixed together.

Materials: Each pair of students should have
marbles
BB's
sand
bottle

Instructions: Place the BB's in the bottle. Measure the height in the bottle, and note the weight.
Now place the marbles on top of the BB's, and measure the total height and note the weight. Put the results in the table.

	Height	Weight
BB's	___	4 washers
marbles and BB's	___	10 washers
Now mix the marbles and the BB's	___	
marbles and BB's (after mixing)	___	10 washers

Now repeat the same procedure using the same amount of BB's and, instead of marbles, an amount of sand weighing 8 washers.

	Height	Weight
BB's	___	
Sand and BB's	___	___
Sand and BB's (after mixing)	___	___

Discussion:
1. Is the weight of the mixture changed after mixing?
2. Will the changes in volume occur with all sizes of particles?
3. Is there any relationship between the size of particles and the amount of volume reduction?
4. Is this the 'true volume'?

Activity 5

Purpose: To describe how you would find the 'true volume' of a granular solid and to describe what happens to the 'true volume' when you mix it with another granular solid.

Materials: Each pair of students should have
styrofoam cup
granular solids (Beans and Stones)
medicine cup
styrofoam tray

Instructions: Remember the last activity where two things were mixed. What happened to the volume when you shook the container? Now measure the number of medicine cups of stones you have. Put the stones into the styrofoam cup. Find out how many medicine cups of water you must pour in so as just to cover the stones. Now subtract the volume of the water from the volume of the stones and you will have the 'true volume' of the stones.
Do the same thing with the beans as you did with the stones and you will find the 'true volume' of the beans.
You now know the 'true volume' of the beans and stones. Now mix the beans and stones and find the 'true volume' and compare it to the 'true volume' of the objects taken separately.

Discussion: 1. Does the water fill the spaces between the stones better than the BB's did in the last activity?
2. Why is water a better substance to use in finding the 'true volume' than, say, BB's?
3. Is the sum of the true volume of the beans and stones the same as the true volume when they are mixed?

DENSITY-VOLUME - UNSTRUCTURED STYLE

Activity I

Purpose: To describe what happens when liquids are placed in other liquids.

Materials: Each pair of students should have
4 medicine cups of liquids
medicine dropper
styrofoam tray

For the class
paper towels
newspapers

Instructions: After obtaining a medicine cup of each of the colored liquids, find out which of the liquids is the heaviest and which is the lightest.

Discussion:

Activity II

Purpose: To compare the density of salt and fresh water.

Materials: Each pair of students should have
3 medicine cups
medicine dropper
styrofoam tray

For the class
food coloring kit
paper towels
newspapers

Instructions: Using the materials, find out what happens when salt water is mixed with fresh water, and try to find the heaviest or the most dense.

Discussion:

Activity III

<u>Purpose:</u> To determine if there is a relationship between weight and density.

<u>Materials:</u> Each pair of students should have
medicine cup of each of the four liquids
equal arm balance
washers
styrofoam tray
medicine dropper

<u>Instructions:</u> Compare the weight of the liquids to whether or not they float or sink in another liquid.

<u>Discussion:</u>

Activity IV

<u>Purpose:</u> To describe what happens to the volume and weight of two objects when they are mixed together.

<u>Materials:</u> Each pair of students should have

marbles
BB's
sand
bottle

<u>Instructions:</u> Compare the total volume of a mixture to the sum of the volume of the objects taken separately.

<u>Discussion:</u>

Activity V

Purpose: To describe how you would find the 'true volume' of a granular solid and to describe what happens to the 'true volume' when you mix it with another granular solid.

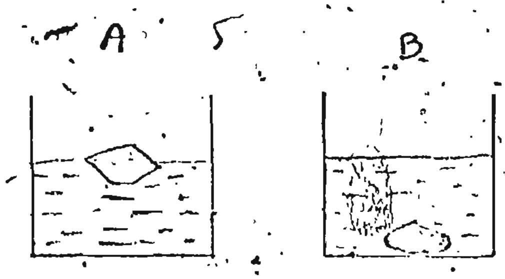
Materials: Each pair of students should have
- styrofoam cup
- granular solids (Beans and Stones).
- medicine cup
- styrofoam tray

Instructions: Using water, instead of BB's like you did yeaterday, find the 'true volume' of the stones and beans. Then compare the sum of the 'true volumes' of the stones and beans with their 'true volume' when they are mixed.

Discussion:

ACHIEVEMENT TEST II - DENSITY AND MIXTURES

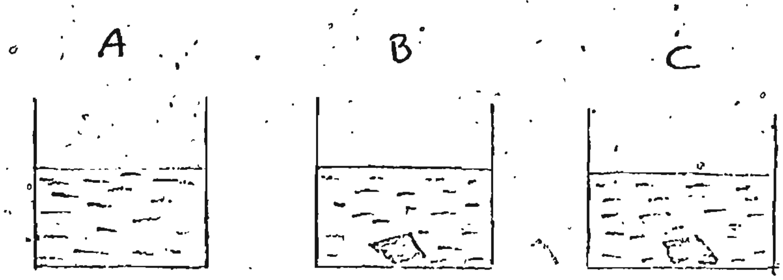
1. Students are required to put a check mark (✓) in the space before the answer of their choice.



In the picture you see two jars of liquid. The object in each jar is the same size and weight. Which of the following could you say about the difference between the liquids in jar A and B?

_____1. Liquid in jar B is heavier than liquid in A
_____2. The liquids are the same in both jars
_____3. Liquid in jar B is lighter than liquid in A

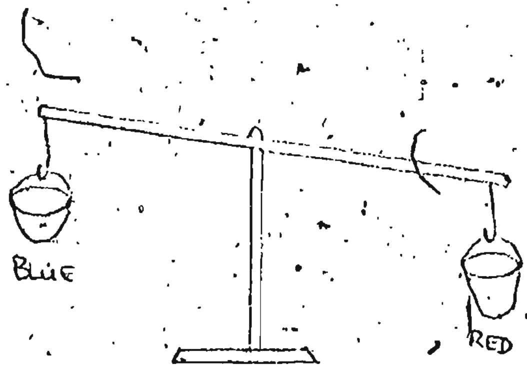
2.



If the object in Jar A were removed and placed into another jar, which we can call jar C, and the object sank, we could say that

_____1. The object in jar C is heavier than object in B
_____2. The liquid in jar C might be the same as in jar A
_____3. The liquid in jar B might be the same as in jar C

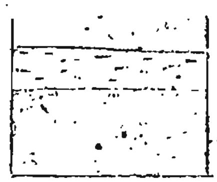
3.



If there is 1 cup full of red liquid and 1 cup full of blue in the containers shown in the diagram, then from looking at the diagram you can say that

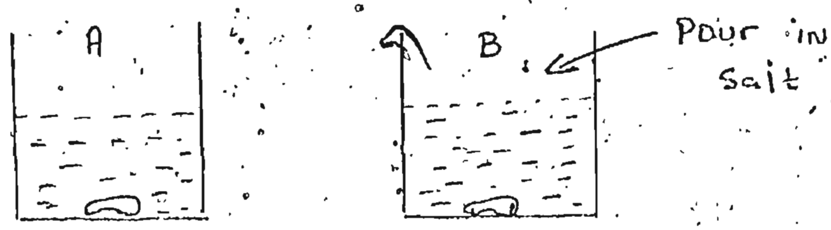
_____1. The blue liquid is denser than the red
_____2. Equal amounts of the two liquids are not the same weight
_____3. The two liquids weigh the same

4.



If you have a jar, like in the diagram, which has some molasses on the bottom and some water on the top of the molasses, what do you think would happen if you placed an object, that was just heavy enough to sink in the water, in the jar?

_____1. It would sink in the water and in the molasses
_____2. It would sink in the water but float on the molasses
_____3. It wouldn't sink in either liquid

5\. 

In the diagram there are two jars of fresh water with a peanut at the bottom of each jar. The peanut is just heavy enough to sink in fresh water. If you pour some salt into jar B, what do you think will happen to the peanut in that jar?

_____1. It will rise to the surface
_____2. It will stay on the bottom of the jar
_____3. It will float up and down

6\. When a river flows into the ocean, the river water will

_____1. sink as it reaches the ocean
_____2. run along the beach near the mouth of the river
_____3. float on the ocean water near the mouth of the river

7\. People who go swimming know that it is easier to float in salt water than it is in fresh water. This is because

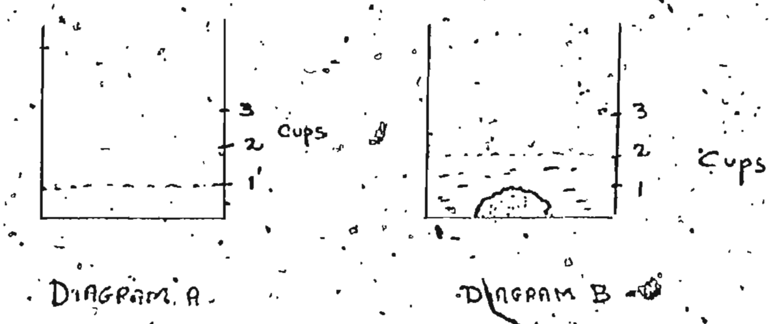
_____1. the salt water is thicker than the fresh water
_____2. the salt water is denser than the fresh water
_____3. the salt water is lighter than the fresh water

8\. 

Which of the above is the best means of finding the volume of a substance?

_____1. Balance
_____2. Screen
_____3. Measuring Cup

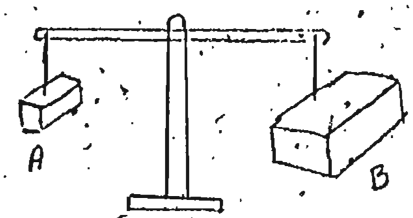
9.



If you have a vial with 1 medicine cup of water in it, as in diagram A, and then put some sand in it bringing the level of the water up to 2 medicine cups, as in diagram B, what is the true volume of the sand?

_____1. 3 cups
_____2. 1 cup
_____3. 2 cups

10.



You will note from the diagram that even though object A is much smaller than object B, it is still balanced. What can you say about the density of A as compared to B?

_____1. A is more dense than B
_____2. B is more dense than A
_____3. A is less dense than B

11.

If you have a container filled up to the spout with water, and you then place a rock into the container, some of the water will overflow. If you collected this water in another container, what can you say about the volume of the rock with respect to the collected water?

_____1. volume of the rock is more than the volume of the water collected
_____2. volume of the rock is the same as the volume of the water collected
_____3. volume of the rock is less than the volume of the water collected

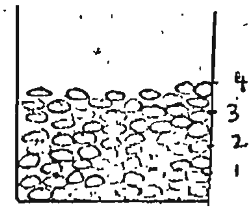
12. Look back at the diagram in number 11. What would happen to the volume of the water in the little container, if you had used an object that was the same size, but much denser?

_____1. the volume of the water would be the same
_____2. the volume of the water would be more
_____3. the volume of the water would be less

13. Look back at the diagram in number 11 again. If you had weighed the water in the small container, and weighed the rock, which of the following could be said about the weight of the water and the rock?

_____1. the weight of the water is more than the weight of the rock
_____2. the weight of the water is the same as the weight of the rock
_____3. the weight of the water is less than the weight of the rock

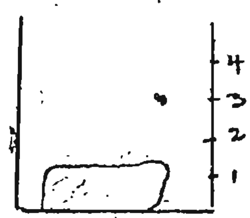
14.



If you measure out 4 cups of peanuts and put them into a container as shown in the diagram, and you know that the "true volume" of the peanuts is only 2 cups, how much water must you pour into the container to just cover the peanuts?

_____1. 3 cups
_____2. 2 cups
_____3. 1 cup

15.



Now instead of peanuts, suppose you had 1 large candy. The "true volume" of the candy is 2 cups. If you now pour into the container 2 cups of water, what will the total volume of the mixture be?

_____1. 2 cups
_____2. 3 cups
_____3. 4 cups

PREFERENCE INSTRUMENT

NAME ______________________ SCHOOL ______________________

Read each statement carefully and place a check mark ( ) in the blank underneath the name of the activities that applies best to the statement.

	Balancing	Liquids
1. During which set of activities did you feel <u>more relaxed</u>?	________	________
2. Which set of activities did you find <u>better</u>?	________	________
3. Which set of activities did you find <u>more confusing</u>?	________	________
4. What were the <u>more pleasant</u> activities?	________	________
5. In which activities did you <u>learn more</u>?	________	________
6. Which was the <u>harder</u> set of activities?	________	________
7. Which activities were <u>more exciting</u>?	________	________
8. What was the worse set of activities?	________	________
9. What activities were the <u>more useful</u>?	________	________
10. During which activities were you <u>more clear</u> about what you were doing?	________	________