INTERACTION PATTERNS OF SEVENTH GRADE SCIENCE TEACHERS

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To S.I. Obeng, my village school teacher, whose enthusiasm and dedication to his pupils set me on this path.

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ABSTRACT

An interaction analysis category system, the Activity Categories Instrument, was used to study the behavior patterns of seventh grade science classes using activity-oriented science units. A preliminary survey showed that all the teachers depended equally on the curriculum guide but failed to establish any strong relationship between biographical and behavioral characteristics of the teachers (with the exception of experience).

Five selected indices of instructional strategies were examined to determine:

a) the extent of teacher indirectness in teaching the lessons,

b) the extent of student participation in practical activities in the science class,

c) the proportion of teacher questions,

d) the extent and nature of teacher talk as well as student talk during discussion (fourth and fifth indices).

The results revealed a significant degree of teacher indirectness and a corresponding degree of student participation in practical activities, but a low degree of teacher questioning, particularly during practical activity. The analysis of the results also showed a possible relationship between the subject matter and teaching strategy. Teachers tended to talk uninterrupted for a greater part of discussion time, while student uninterrupted talk was generally low. Observation showed no major differences in structure and procedure of science classes (majority of lessons being the Elementary Science Study - ESS - science units) with experiments structured in content and procedure.

The size of classes, split classes, lack of adequate laboratory facilities and the ungraded nature of the units were some of the problems in teaching activity-oriented science perceived by the teachers.

The observation instrument was not found adequate to determine the cognitive aspects of the instructional strategies, and it was recommended that two or more observation systems be used in order to ascertain the level of student cognitive functioning associated with these strategies.

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CHAPTER I

INTRODUCTION

Laboratory lessons have been stressed as an important factor in the acquisition of science knowledge at all levels of education. Several studies have shown the positive relationship of the laboratory approach - which has been inconsistently referred to as either a discovery or an inquiry approach - and the attainment of meaningful scientific skills. In the elementary school curriculum of British Columbia as in the school systems of other developed and developing nations science is assuming relatively more importance. The B. C. Department of Education through its revision committees in science education has prepared curriculum guides intended to give the science teacher some guidance in handling his science program. The philosophy that science in the elementary school should be exploratory is fully acknowledged in these guides.

> Science is largely experimental and the teaching of it should, therefore, be based on observation and investigation. A good science lesson is an inquiry, an investigation. The class should be led from the familiar everyday application of science to enquire further into its nature...... Whenever possible the investigations should be performed by the students themselves,... Demonstration work by the teacher should also have the nature of investigation, with the whole class participating...The question and answer lesson is still necessary and the lecture-type lesson should be used when necessary. As a rough guide 40-50% of the time should be spent in individual laboratory work.*

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*Province of British Columbia, Department of Education, Division of Curriculum, Elementary Science, Years 1-7, Victoria, 1969.

Hence it is to be expected that much of the activity in the class will be student-centered, a program that helps the child to observe, hypothesize and infer - to acquire all the attributes of modern scientific inquiry.

How can this objective be achieved in the science classroom? This study is based on the belief that direct observation of science classroom activities offers great potential for discovering some of the problems in and developing new strategies for the realization of this goal. "Direct observation can and should be used in the search for effective patterns of teaching-learning behavior." (Ober, 1971)

STATEMENT OF THE PROBLEM

Analysis of pupil and teacher behavior through direct observation in the classroom has been in extensive use in recent years. This method is most often used for purposes of teacher training and supervision. It could well be used in the field of elementary science education where, even though, the value of practical activities has received general acceptance, the nature of such activities has still to be clearly presented to teachers. As studies in classroom interaction in other disciplines have revealed, in order to achieve some desired objectives to the exclusion of others, it is necessary that specific kinds of behavior patterns be exhibited by the teacher. But in the field of elementary science little is known about desirable behavior patterns, since most of the work reported derives from survey questionnaires or experimental studies using other research designs. This may result from the newness of science as an integral part of the elementary school curriculum. Besides, the proliferation of science units based on varying psychological and philosophical foundations has compounded the teacher's problem in adapting to the new elementary science.

In the face of this problem, it becomes necessary to investigate the classroom climate as a prerequisite to determining a strategy that would result in maximum student learning in a laboratory-oriented elementary science program. In a broader framework the problem may be seen as:

1. The need to explore the nature of interaction patterns in science lessons in order to discover general characteristics of teaching and learning in the science classroom. (An exploratory study).
2. The need to determine the relationship between teacher-pupil interaction and pupil achievement; And
3. The development of necessary interventions for the achievement of desired objectives in relation to stage 2 above, i.e. an effective pre-service and in-service program for teachers of science.

PURPOSE OF THE STUDY

The study was addressed to the first problem outlined in the statement i.e. to conduct an exploratory study to determine the general characteristics of classroom interaction of a sample of Seventh Grade Science classes. In order to achieve this purpose two objectives were set up.

Minor Objective

This was to determine the general characteristics of seventh grade science teachers in relation to their experience, academic and professional training, the instructional aids and other pertinent infromation. For this purpose a questionnaire was constructed and tested in a selected school district. After analysis of the returns of the questionnaire it was found necessary to revise the questionnaire for the main study.

Major Objective

The major objective was to conduct a descriptive study of classroom interaction of selected seventh grade science teachers. This objective was to be achieved by:

1. Examination of biographical characteristics of the teachers.
2. Direct observation of selected seventh grade science classes using a standardized instrument.
3. Analysis of the behavioral data with respect to selected indices described as Activity Ratio, Laboratory Ratio, Questioning Ratio, Student Extended Talk Ratio and Teacher Extended Talk Ratio.
4. Examination of any other factors emerging from questionnaire data or direct observation.

Instruments

The instruments used for this study were:

1. A questionnaire designed purposely for the study, and further revised through a pilot study. The revised questionnaire is shown in Appendix B.
2. A modified system of Flanders' Interaction Analysis category system, the Activity Categories Instrument (ACI) developed by Caldwell (1970) (See Appendix C). This is an eleven-category instrument designed as a quantitative model for evaluating science

lessons through direct observation. The instrument was first developed and validated at Syracuse University and has been used since for observation of elementary science lessons in the United States and in methods courses in West Virginia and Syracuse University.

The eleven categories are subdivided into two main sections i.e. student-centered and teacher-cantered activities. Student-centered activities include open-ended laboratory experiences, structured laboratory experiences, student group work and group and individual demonstrations done independently or with minimum assistance from the teacher, student talk, and student library research.

Under teacher-centered activities are student-workbook work, teacher demonstration, and lecture.

Teacher questioning and havoc are the remaining categories which do not fall into either two sections.

Selection of the population and sampling procedure

The greater Vancouver Area where this study was conducted covers about 9 school districts shown in Table I. Using size and accessibility as the criteria Coquitlam School District was selected for the preliminary study while the larger Surrey District was selected for the main study.

For the preliminary study all the subjects in the population were used for the analysis. In this study certain assumptions were made with regards to the influence of biographical data on teaching method and the selection of resources. Among these assumptions were experience, academic and professional background, number of grades taught as contributing factors to teaching method and resource selection. The criterion for "experience" was based on the time of introduction of the new curriculum guide in 1968. Teachers who taught science before

TABLE I

SCHOOL DISTRICTS

OF GREATER VANCOUVER AREA

Number of District	Name of District	Number of Elementary Schools
36	Surrey/White Rock	60
37	Delta	21
38	Richmond	35
39	Vancouver	90
40	New Westminster	9
41	Burnaby	38
43	Coquitlam	25
44	North Vancouver	35
45	West Vancouver	13

1968 being the experienced or "long service" and those entering the service in or after 1968 "short service". These assumptions were to form the rationale for sampling procedure in the main study. However, they were not supported by the results of the preliminary study, making it necessary to consider the sample for the main study in toto, rather than as members of particular groups.

Rationale for the selection of the population

Selection of the grade was based on a careful examination of the Curriculum guides of the British Columbia Department of Education, Grades I - VII (Elementary Science), 1969, Grade VIII (Junior Secondary School Science), 1968. Grade VII science was chosen, since it is the last stage of the elementary science and therefore serves as a transition between elementary and junior secondary science. The Grade VIII science as the beginning of a sequence covering Grades IX and X, in contrast to the elementary school science, covers specific areas - Biology, Chemistry, Astronomy and Geology. Further, the Curriculum Guide for Science I - VII suggests various alternative methods that lend themselves to separate investigation with respect to classroom interaction, though this is beyond the scope of this study. For example, the development of separate courses designed for particular groups of students, or the design of "a core material for all students and enriched materials for some" is recommended as a means of meeting the needs and abilities of all types of students.

Significantly, the Science I - VII guide recommends the use of the generally student-centered elementary science materials recently developed through various science curriculum projects. Specified for Grade VII science instruction generally, are the Elementary Science Study (ESS) and Elementary School Science Project of the University of Illinois (ESSP-ILL) science units. These curriculum approaches satisfy the main requirement of this study - the study of activity-oriented science lessons.

DEFINITION OF TERMS USED IN THE STUDY

Activity-Oriented Lesson: In this study this refers to any science lesson that affords the learner the opportunity for physical manipulation of objects as a major means of learning.

Activity Ratio: The ratio of time spent in student-centred activities to time spent in teacher-centred activities as described by the Activity Categories Instrument (See Figure 5, Appendix C).

Category System: One of two basic kinds of observation systems. A category system provides classification of behavior that the observer learns, and at intervals during observation determines in what category an observed behavior falls and records that category number.

The other kind is the Sign System, that lists a number of specific incidents of behavior that may or may not occur during the observation period. The observer simply checks once (irrespective of frequency of occurence) each behavior that occurs during the observation period.

Classroom Climate: Refers to generalized attitudes toward the teacher and the class that the pupils share despite individual differences.

Classroom Interaction (Behavior): Teacher-pupil contacts or verbal and non-verbal behavioral acts that occur in the classroom.

Direct Teaching Strategy: Teaching-learning situation where there is more teacher activity than student activity.

Indirect Teaching Strategy: Teaching-learning situation where there is more student activity than teacher activity.

Interaction Analysis System: A system that enables one to quantify, and analyse specific classroom behavior. In this study the term refers specifically to the system developed by Ned Flanders.

Laboratory Experiences: Any independent practical investigation or experiment (simple or complex) carried out in the classroom by the student to discover relationships between a set of objects or ideas. This need not be in a special laboratory.

Laboratory Ratio: The proportion of time spent in laboratory experiences to the total time spent teaching science.

Long Service Teachers: Teachers with science teaching experience of more than three years.

Observation System: An organized objective means of looking at classroom behavior or interaction.

Questioning Ratio: Questions as a fraction of total teacher talk.

Short Service Teachers: Teachers with less than three years of science teaching experience.

Student Extended Talk: A situation where a student talks uninterrupted for an interval of more than ten seconds. This may be successive talks by more than one student without interruption by the teacher.

Systematic Observation: A method of organizing observed teaching and learning acts in a manner which allows any trained person who follows stated procedures to observe, record and analyse interactions so that others viewing the same situation would agree, to a greater extent, with his recorded sequence of behavior.

Teacher Extended Talk: A situation when a teacher talks uninterrupted by a student or his own questions or other activities for a period of more than ten seconds.

Teaching Strategy: A pattern of teaching acts that serves to attain certain results and guard against certain others.

Verbal Behavior: Any action of a teacher or student that is expressed by talking.

CHAPTER II

REVIEW OF THE LITERATURE

The literature was reviewed to reflect the two major ideas embodied in this study i.e. the new "student-centered" science curricula and the use of systematic observation of classroom activities for determining and developing effective teaching strategies. As an exploratory study an elaborate exposition of theoretical constructs underlying these two basic ideas was not attempted, though a brief rationale based on certain concepts of instructional theory or science curriculum development was outlined where necessary.

THE ELEMENTARY SCIENCE

Social Implications of Science Education

The main concern over elementary school science in North America has been for its improvement which focuses mainly on the identification of defensible objectives, reconstruction of the curriculum, utilization of pupil interests, studies of concept development and learning, encouragement of inquiry and discovery, evaluation of achievement, development of effective teaching resources, and more adequate pre-service and in-service education.

The development of the new science curricula has not departed significantly from the underlying philosophies of education in the democratic process. In this framework the educational process should operate under four cardinal principles important to effective and satisfying personal and social life. These are:

1. The recognition of the importance of the individual as a human being;

2. Opportunity for wide participation in all phases of activities of the social groups in the society;
3. Encouragement of variability rather than demanding a single type of personality;
4. Faith in intelligence as a method of dealing with important problems rather than depending on an autocratic or aristocratic authority (Tyler, 1949).

New Directions and Relevant Research in Science Education

In the context of the development of the science curriculum as in other subjects, the emphasis is now on inquiry and discovery approach which is in accordance with the social principles outlined above. For the past few years a collection of curriculum packages have been developed under various projects. These units, though they may differ in content, have a common characteristic in that they rely on child involvement in the process of inquiry - much more manipulation of objects than regurgitation of scientific facts pouring from the direction of teachers.

The Elementary School Science Project of the University of California, Berkeley, designed instructional units built on fundamental concepts, units which would foster inductive thinking (Scott, 1962). The Elementary Science Study (ESS) of Educational Services, Incorporated, Mass.(Nichols, 1964), depending largely on an intuitive approach has designed a series of curriculum units that enable the child to "work with his own hands, mind and heart."

The Science Curriculum Improvement Study (SCIS) of the University of California, Berkeley (Karplus, 1970), has developed a program based on hierarchical arrangements of levels of abstractions and aimed at establishing or reinforcing an abstract concept. These units too revolve around extensive laboratory experiences and phenomena, a process referred to as the "direct approach." It is the belief of the authors that science taught through the laboratory approach simulates the natural way that children acquire understanding. Teaching should not be only talking and listening, a method of teaching referred to as the "indirect approach." The "direct approach" affords a two way system of feedback between the learner and the teacher. The teacher becomes a catalyst, guide, observer as well as an evaluator of the program, the child, and himself. The child becomes an inventor, synthesizer and evaluator while at the same time there appears a three way communication between him, the teacher and the other children.

Science - A Process Approach, a program developed by the Commission on Science emphasizes the skills basic to further learning in science (AAAS, 1968). This also takes the laboratory or behavioral approach. In a series of hierarchically planned lessons the child is introduced to a variety of useful science content while gaining experience in classifying, communicating, measuring, using numbers, observing and using space-time relationships in the primary grades. In the later stages the exercises increase in complexity to formulating hypotheses, making operational definitions, controlling and manipulating variables, formulating models and interpreting data.

Various other projects like the Mathematics and Science Teaching Project of the University of Minnesota. The Oakleaf Individualized Elementary School Science Project (University of Utah), the Elementary

Science Project (Howard University) (designed to create a program of science experiences for disadvantaged children), the Intermediate Science Curriculum Study and many others, though they may differ in specific strategies, all emphasize "inquiry", "discovery" or "inductive" approach as a means of acquiring scientific knowledge.

The necessity for reliance upon scientific inquiry as a means of achieving the required performance in science education has been revealed in many research findings. These studies revolve around the theory that when pupils behave in the way scientists do, they are experiencing science rather than just learning about it; this entails involvement in the development of principles and generalizations, rather than acquisition of learning through reading or expository methods.

Suchman (1960) in a study into the problems of teaching skill in inquiry to elementary school children concluded that fifth-grade pupils can improve their skill in inquiry and become more productive in their use of questions. He also noted that their transfer of strategies to new problem situations is enhanced. There were increments in understanding of content as skills of inquiry developed. However, pupils had little interest in the method for itself, the chief motivating factor for their performance being the desire to understand the problem situation.

Bennet (1966) argues that one of the prime objectives to be considered in elementary school teaching is the "involvement of students in open-ended education experiences utilizing scientific method of inquiry to instill in the students a feeling of accomplishment related to individual initiative necessary for simple experimentation."

Thus, the affective or motivational aspect of the process of inquiry is acknowledged. The usefulness of this method can be seen in terms of generating creative student interest and increasing student self-motivation to seek knowledge.

Washton (1966) hypothesized that problem-solving, open-ended experiments and research projects, if taught under given conditions can promote student creativity in science classes. Some of these conditions may be stated as:

1. freedom for the student to ask thought provoking questions;
2. freedom to question accepted ideas and practices;
3. modification or rejection of original ideas without ridicule or penalty;
4. freedom in requesting a substitute assignment of a (more) creative potential.

Atkins (1958) conducted a study to ascertain the nature of children's development in certain aspects of their abilities to formulate and suggest tests of hypotheses in science learning experiences, and to discover what relationship exists between relative permissiveness of the classroom situation for problem-solving activities and the development of these abilities.

Among the significant findings of this study were that

1. children at upper levels use authority as the basis for hypothesis more frequently than children at lower levels,
2. among the younger children, observation is used as the basis for hypothesis,
3. in a permissive atmosphere children used authority as the basis for hypothesis less than children in a less permissive

atsmosphere,

4. children in the permissive classrooms made "original" guesses more frequently.

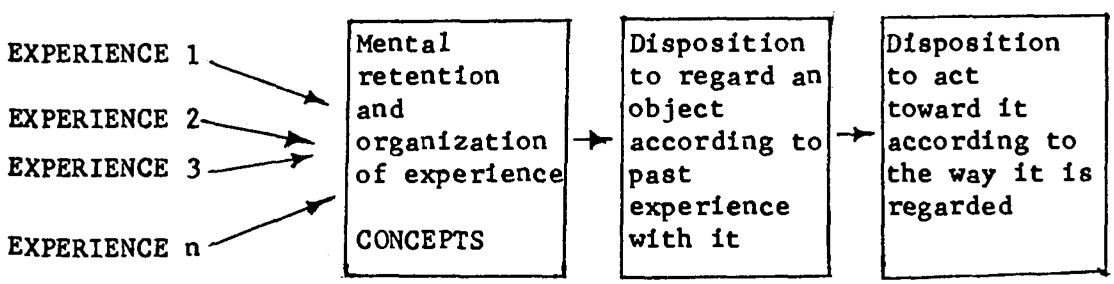
Other studies pertaining to total involvement of the pupil in the learning process were conducted by Croxton (1936), Eaton (1966), Haupt (1948) and Hill (1947). Croxton concluded that the inability of some pupils to make generalizations from science content may be due to lack of sufficient experiences with content as a basis for generalizations and not lack of ability to generalize. Hill noted the need for more time to be devoted to investigating, discussing and sharing ideas. This would enable pupils to increase their ability to question, identify, speculate, recognize relationships and draw conclusions. Eaton (1966) conducted a study into the relationship of number of questions, activities and incongruities contained in printed materials used by sixth grade students and the achievement of these students. He found that only one factor - the number of activities produced any significant difference in achievement.

Of interest, too, are the conclusions of Scandura (1962), Crabtree (1962), Butt (1963, 1965) and Carpenter (1963). Scandura showed that when there was adequate readiness for problem-solving methods, children solved new problems based on principles developed through problem-solving. Where problem-solving methods were used without preparation or experience students tended to memorize procedures as they had previously memorized facts in the traditional approach. Carpenter comes out in favour of a problem-solving, activity-type approach to instruction. Butt found after confronting intermediate grade pupils with a science phenomenon and giving them freedom of activity, that while self discovery is rewarding and motivating, it must depend on external direction which focuses attention on the relationships involved. Independent manipulation of data is not sufficient for concept development. Crabtree's findings seemed to favour an unstructured investigation in science rather than the step-by-step procedure.

Science Education and the Learning Theories

The ideas expressed in the research studies reviewed and the underlying principles in the development of the new science curriculum projects may be viewed in some psychological and theoretical context. All learning begins with some form of personal contact with objects, events, or circumstances in life. Concepts are formulated as a result of perceptions occurring through this contact. Each contact plants a bit of meaning in the mind, which is added cumulatively to all related meanings the mind has already acquired. Thus, it seems, the underlying factor is stimulus or contact, summation of which may be referred to as the "experience". These experiences subsume physical as well as logical-mathematical experiences*.

Perhaps, Woodruff (1970) in a scheme shown below better illustrates how in general learning situations concepts are formed from the learner's experiences.



*Physical experience conforms to our usual notions of acting on objects and gaining some knowledge about the objects through the process of abstraction. Logical-mathematical experience is drawn from the actions effected on the objects.

These later become predispositions for future behavior, something similar to the "familiarity - knowledge - understanding - application" principle. The cardinal point here is the experience one acquires as a result of contact with the object. This underlines the extreme importance of direct manipulation of objects in the science learning situation. The application of this experiential principle of learning may be illustrated with the attainment of a general concept such as "Liquid has no shape". Contact with various kinds of liquid and shapes implants the properties of matter and measurements i.e. the experience with these in the brain of the learner.

REFERENT		CONTACT		CONCEPT
Water		observes water		water (Exp. 1)
ink		observes ink		ink (Exp. 2)
...	→	...	→	...
shape		observes shape		shape (Exp. n)
liquid		observes (ink, water..)		liquid (Exp. n+1)

SUM OF EXPERIENCES → Liquids have no specific shape. Container has shape. → Milk - Liquid will assume the shape of container.

↓

Specific amount of milk needs specific "shape" of container. → Concept of volume-unit of measurement → etc...

These four or more experiences may lead the child to formulate the concept of shape and that "liquids have no shape of their own" and lead him to various generalizations through conceptualization.

Gagne (1970), in a much more restricted sense of the meaning of concept, agrees that a concept learned by way of verbally stated principles may have some inadequacies.

> If the student is to learn concepts like "power", "energy", "osmotic pressure", and many others, he can ... learn them by means of definitions. But there is a danger that the concepts he learns this way are inadequate in one way or another. Accordingly most science educators would maintain that the performing of operations, including observation in the laboratory, is an essential part of the learning situation required for the learning of fully adequate, generalizable concepts. The role of the laboratory in school learning serves to remind us of the concrete basis for learning concepts and of the potential insufficiencies of concept-learning which is based solely on verbally conveyed definitions.

These theories give substance to theories of learning by discovery, or the laboratory approach to teaching science. "Learning by discovery" advocates the teaching of broad principles, and problem-solving through minimal teacher guidance and maximal opportunity for exploration and trial and error on the part of the student. Bruner (1970) describes the child as moving through three levels of representation:

1. The enactive level, where the child manipulates materials directly;
2. The "ikonic" level, where he deals with images of objects but does not manipulate them directly (vicarious learning); and
3. The symbolic level, where he is strictly manipulating symbols and no longer images of objects.

Another school of thought, "guided discovery learning" emphasizes the importance of sequential instructional experiences through maximum guidance: the importance of basic associations or facts in the service of eventual mastery of principles and problem solving. Gagne (1965) describes problem solving as the highest stage of learning in a hierarchy of learning capabilities:

↑ PROBLEM SOLVING
PRINCIPLE
CONCEPT
MULTIPLE DISCRIMINATION
VERBAL SEQUENCES
CHAINING
STIMULUS-RESPONSE

If problem solving is to be used successfully in science, then according to the principle of guided discovery it is imperative that all the prerequisite learnings be achieved. In relation to science education these may be set out as:

<u>Stage 1</u>. Basic types of learning including stimulus response learning, chaining and verbal association, in which children achieve basic relationship with their environment, both verbal and nonverbal.

<u>Stage 2</u>. Multiple discrimination learning in which children observe physical characteristics of objects and discriminate amongst them.

<u>Stage 3</u>. Concept learning in which children use knowledge acquired in previous phases to acquire generalized notions of classes of objects.

<u>Stage 4</u>. Principle learning in which children, through experiences in classifying, measuring, space-time relationships, communicating, and inferring, come to recognize and formulate statements of relationships among concepts that are of continuing applicability.

<u>Stage 5</u>. Problem solving in which children through the application of previously derived principles to new situations solve problems and emerge with higher order principles which, in turn, may be applied to future problems.

In summary, it may be said that in elementary science education, despite the differences in approach, the focal point is the activity type science lesson. The various theories of learning proposed by Gagne (1965), Bruner (1970) Karplus (1969) are epitomized by Woodruff's theory - the cardinal point being the child's contact with concrete objects or phenomena forming experiences that are retained or reorganized mentally into a conceptual framework for reinforcing or attaining further learning.

INTERACTION ANALYSIS - A SYSTEMATIC OBSERVATION OF LEARNING ACTIVITIES

Introduction

An activity-oriented science lesson should provide the children with the opportunity for the exploration of ideas verbally, and practically with materials. Such a lesson is characterized by a variety of challenging experiences which enable the pupils, by the use of simple manipulative materials, to investigate important science questions in their physical and biological environment.

Although direct manipulation of objects by the pupils is emphasized in the new science units or curricula, the teacher's role in the science class is not in any way diminished. Rather, the new science approach poses a challenge to the science teacher, since the teacher has to interact with the pupils in a manner that will generate the desired method of learning. The teacher's method of questioning or general verbal discourse with the pupils may either induce or stifle the creativity of the child. Theoretically, teacher behavior can be structured to elicit more efficient thought processes or thinking skills from students (Simon, 1967). The teacher's verbal behavior carries as part of its content prescriptions on how to think.

> A teacher who asks only data recall questions is prescribing a different thought process than one who asks questions requiring pupils to process data. These prescriptions are the "what" of teaching children how to learn.

Not only the verbal behavior, but also the general classroom behavior of the teacher are characterized by a degree of consistency and are observable, distinguishable and qualitatively and quantitatively classifiable. In order to determine the verbal behavior of the teacher in the classroom, several methods of observation of teacher-pupil interaction have been systematized by various investigators. Simon and Boyer reviewed extensively most of the category systems that have been devised and used in numerous studies. Most of these are research tools, others by their nature lend themselves for use as intervention in teacher training and supervision. In the first category the most widely used is the system developed by Ned Flanders. In the latter, the Teaching for Inquiry system developed by Theodore Parsons (University of California, Berkeley) may be cited as an example. Birch (1969) has indicated its potential as a clinical method for self-analysis.

Flanders' System of Interaction Analysis

Flanders' original system of interaction analysis consisted of ten categories, i.e. teacher accepts student feelings, 2) teacher praises student, 3) teacher accepts student ideas, 4) teacher asks questions, 5) teacher lectures, 6) teacher gives directions,

7) teacher criticizes student, 8) student answers with fact, 9) student answers with opinion or concept, and 10) silence and confusion.

Earlier Anderson (1946) and Cogan (1956) had described classroom interaction in their research and attempted to classify teacher behavior in the classroom. Anderson saw patterns of classroom climate as essentially dominative or integrative (see summary of Anderson's classifications in Figure 1) something Cogan (1956) refers to as "preclusive" and "inclusive". Later researchers modified these classifications into teacher-centered and pupil-centered. While these classifications of teacher behavior give indications of teacher attitudes and contribute to theory of instruction, they are not consistent enough and lack flexibility in order to be used to explain the effect of short term patterns of teacher influence on momentary situations.

Flanders (1969), in an attempt to correct the lack of flexibility in the earlier classifications introduced a new system which maintained the basic characteristics of the Anderson classification. He introduced the concepts "direct influence", and "indirect influence", which are a measure of the child's "dependence".*

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*Dependence: Flanders defined dependence as the essential qualities of the superior-subordinate relationship between the teacher and the pupil. There are three degrees of "dependence" - high, medium, and low. High dependence refers to a condition in which pupils voluntarily seek additional ways of complying with the authority

Direct Influence consists of stating the teacher's opinion or ideas, directing the pupils' actions, criticizing behavior or justifying his authority or the use of it.

Indirect Influence consists of soliciting the opinions or ideas of the pupils, applying and enlarging on these opinions and ideas, praising or encouraging the participation of pupils, or clarifying and accepting their feelings (Flanders 1967). All these general concepts of teaching methodology were constructed into a systematic observation instrument comprising 10 categories. This instrument is generally referred to as Flanders' System of Interaction Analysis. A summary of this system is shown in Figure 2.

In later studies Flanders' original system was expanded or modified. Amidon and Hunter (1967), using the same approach, designed the Verbal Interaction Category System (VICS) which may be used to study verbal behavior in the classroom. The VICS consists of five major categories subdivided into eleven categories viz. 1) Teacher-initiated talk, 2) teacher response, 3) pupil response, 4) pupil-initiated talk, and

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of the teacher. Medium dependence - average classroom condition in which teacher direction is essential to initiate and guide activities but the pupils do not voluntarily solicit it. Low dependence - pupils react to teacher directions if they occur, but their present activities, usually teacher-initiated, can be carried on without continued teacher direction. Independence refers to a condition in which the pupils perceive their activities to be self-directed.

	INTEGRATIVE PATTERN	DOMINATIVE PATTERN
1.	Accepts clarifies and supports ideas and feelings of pupils.	Expresses or lectures about own ideas.
2.	Praises and encourages.	Gives directions or orders.
3.	Asks questions to stimulate pupil participation in decision making.	Criticizes and deprecates pupil behavior with intent to change it.
4.	Asks questions to orient pupils to school work.	Justifies his own position or authority.

FIGURE 1

CLASSIFICATION OF TEACHER

BEHAVIOR AND PATTERNS

BY ANDERSON

TEACHER TALK	INDIRECT INFLUENCE	1. Accepts Feeling: accepts and clarifies feeling tone of the students in a non-threatening manner. Feelings may be positive or negative. Predicting and recalling feelings are included.
		2. Praises or Encourages: praises or encourages student action or behavior. Jokes that release tension, not at the expense of another individual nodding head or saying "uh huh?" or "go on" included.
		3. Accepts or Uses Ideas of Students: clarifying, building, or developing ideas or suggestions by a student. As a teacher brings more of his own ideas into play, shift to category five.
		4. Asks Questions: asking a question about content or procedure with the intent that a student answer.
	DIRECT INFLUENCE	5. Lectures: giving facts or opinions about content or procedure; expressing his own ideas; asking rhetorical questions.
		6. Gives Directions: directions, commands, or orders with which a student is expected to comply.
		7. Criticizes or Justifies Authority: Statements, intended to change student behavior from non-acceptable to acceptable patterns; verbal chastisement; stating why the teacher is doing what he is doing, extreme self-reference.
STUDENT TALK		8. Student Talk - response: talk by students in response to teacher. Teacher initiates the contact or solicits student statement.
		9. Student Talk - initiation: talk by students, which they initiate. If "calling on" student is to indicate who may talk next, observer must decide whether student wanted to talk. If he did, use this category.
		10. Silence or Confusion: pauses, short periods of silence, and periods of confusion in which communication cannot be understood by the observer.

FIGURE 2

SUMMARY OF FLANDERS' CATEGORIES

FOR INTERACTION ANALYSIS

5) other. Thus, while the Flanders' system takes a general view of the dimension of teacher behavior in terms of directness and indirectness, the VICS system looks at teacher categories in terms of initiation and response. Furthermore, VICS discriminates between "narrow" and "broad" questions of the teacher and expands the pupil talk to elaborate on the type of response elicited from the student. The introduction of "narrowness" or "broadness" of "Teacher Questions" makes the instrument a useful one since it enables the researcher or the teacher to determine the level of thinking.

Hough (1967) expanded the original 10 categories to sixteen to make up for certain inadequacies in the Flanders' system. Hough's sixteen category Observational System for Instructional Analysis (OSIA) was grouped into four major subdivisions:

1. teacher indirect verbal behavior,
2. teacher direct verbal behavior,
3. student verbal behavior,
4. silence or nonfunctional behavior.

The cognitive elements in the Observational System for Instructional Analysis make it more flexible for use in a variety of situations. The more elaborate analysis of "silence" makes this a suitable system for use in a science classroom situation where most of the time may be spent in "contemplative or productive silence". The three categories of "silence" cover, direct practice or activity, silence and contemplation and demonstration with teaching aids. Later development of the OSIA has improved the diagnostic value of this system. The classification of the OSIA into substantive and managerial student-teacher interactions, as well as behaviors associated with "processes of thought" (Hough, 1970) makes this system more comprehensive than most other variations of the Flanders' System. Two additional categories make it possible to record instructionally non-functional behaviors and student to student interaction during discussion. The system also indicates the level of thought processes in broad categories of "closed" and "open" behaviors. A "closed" behavior indicates a convergent application of knowledge, performance of skill and feeling states while an "open" behavior requires a divergent application of these basic cognitive, affective and psychomotor units.

Procedure for recording teacher-pupil interaction

The review of the recording procedure and its analysis will be done with reference to the basic Flanders' system, since the approach is generally the same for all the systems. An observer or a team of observers record the classroom activities either live or from a recorded audio or video tape. Every three seconds the observer writes down the category number of interaction that best describes the activity at the moment. These numbers are recorded in a column and a sequence of interactions maintained and preserved. For example, consider the following science classroom interaction:

Teacher: "Everybody get your materials ready" - (6)*

---

*Figures in brackets denote the appropriate category in the Flanders' 10 category system.

This may be followed by "silence and confusion" as students look for their materials. Then, probably, a teacher direction followed by a student response. For example:

T: "Harry, will you get your materials ready, please." - (7)

Harry: "Sir, I can't find one of my bulbs" - (8)

T: "Unfortunate, will somebody lend Harry a bulb". - (1)

Teacher: "Right, now let's start".
"In a series circuit, the current flows through a source of electricity, (5) through a closed switch, through a bulb, and (5) back to the source, making a round trip." (5) (about 10 seconds of lecture - 5, 5, 5,).

Teacher: "Okay, Why do we need a closed switch?" - (4)

A student answers in about 15 seconds (five 8's)

Teacher: "Very good, now we all know the procedure". - (2)
"Set up your circuits so your flashlight bulbs will light up!" - (6)

An observer will, thus, record the following for the above short session.

10*	5
6	8
10	8
7	8
8	8
1	8
6	2
5	6
5	10*

---

*The number 10 at both ends of the record denotes the beginning and the end of a lesson or a section of it, and also makes the pairing up of the numbers easier.

Analysis of responses in the Flanders' system

The sequence of numbers recorded by the observer (as above) is entered upon n-row by n-column matrix, "n" being the number of categories in the system. These numbers are entered as ordered pairs in cells of the matrix, with the first number in each ordered pair designating the row and the second number - the column of the matrix. For the sequence of behaviors above, an observer would enter matrix tallies for the ordered pairs 10-6, 6-10, 10-7, 7-8, 8-1, 1-6, 6-5, 5-5, 5-5, 5-8, 8-8, 8-8, 8-8, 8-8, 8-2, 2-6, 6-10. Thus each pair of numbers overlaps with the previous pair, and each number except the first and the last appears twice. The number of tallies in the matrix is one less than the numbers entered on the record. After the matrix is set out, totals are computed and the percentage of use made of each type of behavior is calculated.

General aspects of classroom interaction

1. Total Teacher Talk - this is found by adding up the tallies in columns 1-7. The percentage of this over total tallies gives the ratio of teacher talk.
2. Student Talk - similar calculation for columns 8 and 9 gives total student talk and the ratio of student talk.
3. Indirect-Direct Ratio gives the number of teacher indirect statements to direct statements. This is the ratio of tallies in columns 1-4 to those of columns 5-7. ID ratio of 1 means that for every indirect statement there was one direct statement.

$$\text{I.D. - ratio} = \frac{\text{Indirect} \quad (1\text{-}4)}{\text{Direct} \quad (5\text{-}7)}$$

Revised Idirect-Direct Ratio (id-ratio)

The revised id-ratio shows the kind of emphasis given to motivation and control in a particualr classroom. The id-ratio is found by dividing the number of tallies in columns 1, 2 and 3 by the number of tallies in columns 6 and 7. The ratio eliminates the effects of "asking questions" and "lecturing" (categories 4 and 5) and shows whether the teacher is indirect or direct in his approach to motivation and control.

$$\text{id-ratio} = \frac{\text{Categories 1, 2, 3 (indirect)}}{\text{Categories 6, 7 (direct)}}$$

The id-ratio is a factor of teacher effectiveness. A higher id-ratio indicates how receptive a teacher is to students' ideas and feelings. The more receptive a teacher is to students' ideas and feelings the more likely he is to clarify, develop or reinforce these ideas. At the same time a low id-ratio indicates possible disciplinary problems that in turn may impair the effectiveness of the teacher. Hough (1967) drawing on a study by Flanders, stated that high teacher indirectness was associated with high student achievement. For a teacher who is trained in application of systematic analysis, a higher id-ratio may facilitate the use of positive reinforcement to student ideas and responses by avoiding aversive stimuli and responses which may be a function of associative inhibition. Relating the reinforcement theory to Flanders' research in Interaction Analysis, Hough (1967) concluded that:

> Classrooms in which there is a large percentage of question-asking, student-responding, and teacher-reinforcing have a greater achievement than classrooms in which these conditions are present to a lesser extent.

> Classrooms in which there is a small percentage of criticism, justification of teacher authority and sarcasm (aversive stimulation) have a greater achievement than classrooms in which these conditions are present to a greater extent.

The first statement is a factor of high id-ratio while the second gives a low id-ratio.

Interaction Matrix

The interaction matrix is another useful tool for examining patterns of classroom interaction. Specific areas of interest in the matrix are selected for analysis. The total number of tallies in these areas give a picture of the particular teaching strategy that is being employed in a particular classroom (Flanders 1967, 1970).

The Use of Interaction Analysis in Research and Teacher Training

Mason (1970) used Flanders' system in conjunction with Barret-Leonard's Relationship Inventory to determine the relationships between the behavioral styles of junior and senior high school teachers, and the quality of teacher-student interpersonal relationship. No correlation was found between these two variables.

In a study by Johnston (1969) secondary student teachers were taught to use the Flanders' system for self-supervision by analysis of video tapes of their lessons in micro-teaching situation. They were rated on the Minnesota Teacher Attitude Inventory (MTAI) together with student teachers who were supervised in a traditional manner. Among other things, Johnston concluded that self-supervision promotes indirect teaching and tends to promote higher scores on the MTAI. The retention or the long term effects of self-supervision were not investigated, though no significant relationship was found between time and attitude change in the student teaching under traditional supervision.

Flanders' system and the various modifications to it have found much greater application in student or preservice teaching. Moskovits (1967) investigated the influence of the attitudes and teaching patterns of cooperating teachers and student teachers trained in interaction analysis. Two groups of cooperating teachers and student teachers (trained and untrained in interaction analysis) were observed in the following manner:

1. Trained cooperating teachers with trained student teachers.
2. Untrained cooperating teachers with trained student teachers.
3. Trained cooperating teachers with untrained student teachers.
4. Untrained cooperating teachers with untrained student teachers.

The attitudes of cooperating teachers toward teaching and toward their student teachers were most positive when both cooperating teachers and student teachers were trained, and decreased successively in positiveness as the degree of contact of the cooperating teachers with interaction analysis diminished. On the whole, the training in interaction analysis of one or the other party or both enhanced the positiveness towards each other. Another significant result of the study was the degree of variability in the teaching patterns of the cooperating teachers and the student teachers who were trained in interaction analysis. The trained teachers became more individualistic. This finding appears to corroborate those of Flanders (1961) and Swineford (1964) in earlier studies; that matrices of low achieving teachers contained identical teaching patterns, while those of high achieving teachers had patterns differing from teacher to teacher. Swineford found no single characteristic pattern in the teaching behaviors of the highest rated teachers.

Zahn (1965) in a study with student teachers used the interaction analysis as a supervisory technique. This study, too, confirms the positive aspects of training in Interaction Analysis, in that its use in instruction and supervision of student teachers appears to be related to a positive change in the attitudes of the student. This relationship, however, was found to be limited by the strength of the student's belief system. Interaction Analysis as supervisory technique for students with strong belief systems is related to a positive change. As in Moskowitz's study, Zahn found that the effect of cooperating teachers on the attitudes of the student teachers was greater when students were supervised by conventional techniques than it was through the Interaction Analysis technique.

Though Interaction Analysis has been used more widely in social studies, some studies using this method conducted in science education have supported some of the earlier findings in social studies. Flanders (1965) found indirect mathematics teachers to be teachers of higher achieving classes than direct mathematics teachers. This was further supported by Pankratz's (1966) study of classroom interaction of "high rated" and "low rated" teachers of twelfth-grade physics (rated according to three evaluative instruments - Teacher Rating Scale, Student Opinion Questionnaire and Teaching Situation Reaction Test (TSRT)). Using Amidon's modified system - Observational System for the Analysis of Classroom Instruction - Pankratz found that high rated physics teachers used more praise and reward, and more cognitive and skill clarification, than low rated teachers. Questioning occured as frequently in one group as in the other but the cognitive levels of questions were different.

Newport and McNeil (1970) compared the teacher-pupil interaction evoked by the new science program of Science - A Process Approach, and that which was evoked by textbooks. Two groups of teachers who were given a limited training in the use of Science - A Process Approach (SAPA), and Interaction Analysis, taught and taped their lessons which were later analyzed using the Flanders' system. Analysis of the tapes showed that while teachers who were acquainted with interaction analysis but taught from textbooks used more lecture than the SAPA teachers, they used significantly more student ideas than the SAPA teachers. Probably what was significant in the study was the finding that teachers untrained in the use of the new SAPA program did not differ significantly in their methods from teachers who used textbooks. This points out the need for teacher training before the use of the SAPA program. It is difficult, though, to generalize about other new programs since the SAPA program is based on the theory of "guided learning" which may have the tendency to increase pupil-teacher discourse and probably teacher directness. Another finding in the same study emphasizes the need for instruction in the philosophy, psychology and methodology of science education in order to make the use of interaction analysis as a clinical tool more effective.

Citron and Barnes (1970, 1970a) in an attempt to determine a better method for teaching biology to slow learners conducted a long and extensive study into biology classroom interaction by observing and recording on tape the classroom interaction at monthly intervals. Different treatments were given to three groups of slow learners. The first group was taught with a very high Indirect/Direct (ID) ratio decreasing at monthly intervals to a very low ID-ratio, while another group was subjected to a very low ID-ratio increasing to a very high ratio. The third group was subjected to a constant intermediate ratio. Pupil achievement was measured just prior to the change in teacher pattern. In all three achievement measures used (concept formation, problem solving, and total achievement) there was a negative correlation between achievement and ID change, though concept formation and problem solving were differently affected (different correlation coefficients). After further analysis it was concluded that a high ID-ratio at the beginning of the biology course for the slow learners changing to lower ID-ratio later in the course increases achievement in problem solving and total achievement, provided that problem solving plays a major role in the total performance. Secondly, a constant intermediate ID-ratio throughout the course leads to higher achievement in concept formation. In a follow-up (1970a) the effect of constant teaching patterns was further tested. This showed that problem-solving performance among the High School biology slow learners was affected in a positive way by use of more indirect verbal interaction for an extended period, while the use of more extended direct verbal interaction produced negative results. However, in concept formation the results were not very conclusive, which makes it difficult to derive firm conclusions on total achievement (problem-solving + concept formation) since the testing had some bias towards problem-solving. Even so, the study demonstrated Interaction Analysis as a powerful tool for quantitatively determining various aspects of learning theories.

While the Flanders' system is suitable for use in all classroom situations, it fails to account for some specific science classroom situations. Perhaps the category in the Interaction Analysis observation system that best describes the extensive nonverbal activities that goes on in the science classroom is silence or confusion which Amidon modifies into "contemplative silence" and "directed activity". Nonetheless, these categories do not adequately describe the nature of practical or laboratory processes of science classroom interaction.

To compensate for this inadequacy Caldwell (1968) constructed the Activity Categories Instrument (ACI) based on the basic principles of the Interaction Analysis. This takes into account the nature of the science laboratory-oriented lessons. Thus, instead of the usual categories in the Flanders or Amidon systems Caldwell devised new categories that describe the science classroom climate, viz. open-ended laboratory experiences, structured laboratory experiences, group projects, student demonstration, student library research, student speaking. These are described as student-centred activities, while "workbook work", teacher demonstration and teacher lecture are classified as teacher-centred. In addition there are categories for teacher questioning and "havoc". The basic similarity to the Flanders' system is the method of coding and analysis of the data from the results of the observations.

Hall (1970) investigated teacher - pupil behaviors by groups of teachers trained in Science - A Process Approach (SAPA) and those untrained in SAPA. Hall used another modified version of the Interaction Analysis - The Instrument for Analysis of Science Teaching (IAST). This was applied in the classrooms of practising teachers. A 23-category instrument, it systematizes in detail the verbal interaction between the teacher and the pupil. Although it contains categories for "overt silent activity" and "covert silent activity" it is difficult to determine quantitatively by this instrument the extent of activity in the classroom.

However, Hall's results seem to support those of Newport and McNeil (1970) who used the original system of Interaction Analysis. Hall came to the conclusion that contrary to an earlier finding by Westmeyer, teachers trained in SAPA were more direct than teachers using the old curriculum. There was a shift from giving information to giving more procedural directions, which in terms of process-oriented lessons may be equivalent to giving information in content-oriented classes.

Yet another modification of the Interaction Analysis that has been used for science classroom observation is Science Teaching Observational Instrument, which contains five categories - recall facts, see relationships, make observation, hypothesize, and test hypothesis. Moon (1971) used this instrument in conjunction with Flanders' system of Interaction Analysis to analyse selected samples of teacher behavior patterns in primary grade classrooms during science activities. Two groups of teachers, one using units of the Science Curriculum Improvement Study (SCIS) and the other using conventional methods were observed. Comparison was also made between the teaching performances of the SCIS teachers before and after the SCIS program was introduced. The teachers exposed to the SCIS program had significantly higher ID-ratios than the teachers employing conventional methods and materials. This agrees with Hall's study of the Science - A Process Approach program. Moon attributes this phenomenon to a possible increase in percentage of teacher direction-giving to young children actively involved with science materials. The level of questioning of the teachers was raised from a low-order (recall of facts and information) to a higher-order questions, though whether this was due to the introduction of the SCIS program, or the observation instrument, or both, is not clear. The investigator found that there was little retention in time of the methods learned at the workshop for the SCIS units. The teachers assumed a more direct stance as the school year progressed. An explanation given for this is the teachers' compliance with the program's emphasis on carefully giving directions (a measure of directness) to young children before allowing them to handle objects.

Another useful instrument of interaction analysis is the Guided Self Analysis (GSA) (Birch 1969), which is designed specifically to assist teachers in the self-appraisal of their teaching methods consistent with major elements of successful teaching. The theoretical basis of the GSA is founded on the induction of "cognitive dissonance" in the teacher, and its subsequent reduction which results from behavior change provided that:

1. The dissonant facts are not rejected as false.
2. The dissonant facts are not interpreted in such a way as to be seen as consistent with the person's behavior and beliefs.
3. The dissonant facts are taken seriously, causing the person to alter his original assumptions and behavior.

The GSA system seeks to promote the last reaction.

In effect the Flanders system may be used for self analysis in its raw form and has thus been used as a feedback system by some researchers. But its focus on the broad area of human interaction makes it difficult for the user to identify the concomitant factors that enhance the cognitive level of teaching. It is in this area that the importance of the GSA as a clinical instrument asserts itself.

The Teaching for Inquiry Program which embodies the underlying strategies of The GSA system is divided into six "schedules" which focus more on the teacher than on the student. These schedules are Questioning Strategies, Response Strategies, Teacher Talk Patterns, Experience Referents and Levels of Thinking. Each schedule is further divided into categories that help in operationally analysing the behavior concerned. For instance, the Questioning Strategies are designed to find the ratio of questions requiring more complex pupil thinking and a greater amount of pupil thinking activities, to those questions demanding less pupil thinking. Leading questions, probing questions, rhetorical questions, and basic questions make up the Questioning Strategies schedule, and the ratio of the first two categories to the last two make up the questioning index.

Each schedule is coded and analysed individually. Thus a teacher may video-tape himself, code according to a particular schedule consistent with his need for improvement, and try to modify his behaviors to his acceptable ideal in a series of self analyses. The same video-tape can be used to code the other schedules. Thus the resultant cumulative effect can be assessed.

This short review of the GSA was intended as an example of the cognitive systems of the observation of learning activities. Simon and Boyer in their anthology give extensive reviews of both cognitive and affective systems. All the affective systems, except for minor details, are similar. Thus, detailed review of other systems in addition to that of Flanders (the most widely used) may prove redundant.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this chapter is to present an outline of the methods and procedures that were used in the study. The main points to be discussed will be, the preliminary study (construction and administration of instruments) and the main study (constructed and standardized instruments used, administration of the instruments, and the problems involved in the administration of the instruments).

The Preliminary Study

The preliminary study was undertaken to design and refine a questionnaire and to use it to determine the potential relationships between biographical and behavioral characteristics of selected seventh grade science teachers and to use the Activities Categories Instrument (ACI) in a trial observation.

Method

A 48-item questionnaire covering experience, academic and professional training, teaching methods, lesson aids and units used, pupil achievement and interest was constructed.

The questionnaire was distributed through the offices of School District No. 43 (Coquitlam) to Seventh Grade science teachers in the district. In all 48 questionnaires were distributed. Thirty were returned, giving a 60% response.

The data were examined to determine potential relationships between biographical and behavioral (teaching) characteristics of the teachers concerned. The overall science teaching experience, the elementary science teaching experience, credits in advanced science courses, the number of grades taught were chosen as independent variables and tested against the reported science teaching practices including activity-oriented lessons, individualized, small group and full class instruction, and use of curriculum guides and resource units.

These analyses revealed no strong relationships with the possible exception of science teaching experience and activity-oriented lessons. The summary of the results is given in Table II .

The Activity Categories Instrument (ACI) - Trial Administration

The Activity Categories Instrument which was to be used for direct observation in the study was used in a trial observation (after permission for its use had been granted) to a) develop observational skill, b) determine reliability in coding, c) determine the defects, if any, in the method of coding and in the instrument itself and d) establish ground rules for the observation.

Six full sessions of a selected science class (Grade Seven) were observed. Analysis of the six observations revealed a consistency of 0.88 using Scott's Coefficient*. As a result of the trial observation, some minor changes were made in the procedure to be adopted in the main study, notably "simultaneous coding" of events in the classroom. In the original instrument the observer records one of two events that occur, at the same time using his own discretion to choose the category that most aptly describes the situation. In some cases the observer records the category with the lowest number. Thus, in a situation

*Consistency Ratio calculated by Scott's method (for the main study) as a measure of coding stability is described on page 53.

TABLE II

SUMMARY OF RESULTS OF THE PRELIMINARY STUDY.

SINGLE CLASSIFICATION ANALYSIS OF VARIANCE.

Variable		Group Mean		F	Comment
Independent	Dependent	Gp.1	Gp.2		
	Time spent on:				
	1. Activity-oriented lessons	3.50	2.21	7.42*	Mean difference
	2. Individualized instruction	2.40	1.16	21.11*	Mean difference
I. Teaching	3. Small group instruction	1.20	1.32	0.13	No mean diff.
Experience**	4. Class size instr.	1.60	2.32	3.70	No mean diff.
	Use of:				
	5. Teacher-prepared experiments	0.30	0.62	2.98	No mean diff.
	6. B.C. Curriculum Guide	1.00	0.94	0.07	No mean diff.
	Pupil interest rated by teachers	Not statistically analysed. Moderate interest and achievement reported generally.			
	Pupil achievement rated by teachers				

* Beyond 0.01 level of significance.

** Teachers were grouped according to the number of years they had taught science. Group 1 - less than three years. Group 2 - more than three years. $n_1 = 10$, $n_2 = 19$.

II. Teachers grouped according to the number of science courses taken during training and tested against variables 1 to 6 did not show any significant mean differences. F-values for these variables were 0.13,

TABLE II (CONTD.)

2.14, 2.00, 1.49, 0.61 and 0.20 respectively. Group 1 - only introductory courses. Group 2 - introductory and advanced courses. $n_1 = 16$, $n_2 = 13$.

III. Teachers grouped according to the number of grades they were teaching at the time of the study and tested against variables 1 to 6 did not show any significant mean differences. F-values in this case were 5.86, 3.02, 1.66, 0.47, 0.19 and 0.34 respectively. Group 1 - teaching only Grade 7. Group 2 - teaching Grade 7 and one or more other grades.

where a teacher is talking (Category 8) while students are working on an open-ended experiment (Category 1), he records an 8. In simultaneous coding the observer will record instead both 8 and 1 in the same space, thus 1^8, if category 1 was the extended event at the time or 8^1, if the situation was reversed.

In the instrument itself, it was found necessary to interchange the positions of categories 8 and 10. In the original schedule the position of Teacher Talk as category 10 was removed from other categories of verbal behavior, i.e. categories 6 (Student Talk) and 7 (Teacher Talk) by the intervening categories. This made it difficult to design a coherent interaction matrix. However, by interchanging the positions of categories 8 and 10, the student and teacher verbal behaviors were brought into sequence and a more systematic and a workable matrix could be devised. Thus, it was possible to delineate in the interaction matrix the "Discussion Area" which described student-teacher verbal interaction.

THE MAIN STUDY

Instruments Used

The Questionnaire. One of the aims of the preliminary study was to test the questionnaire to be used in the main study. Based on analysis and feedback on the preliminary study the original questionnaire was modified to make it more explicit.

Standardized Instruments. Several systems for observation of classroom climate were considered. Among these systems were: The Guided Self-Analysis Schedules (GSA), which, though potentially useful for analysing teaching strategies, were primarily developed for behavior change through self-analysis. Since coding of classroom activities was to be done live, it was essential that the system used be short and inclusive. The original Flanders' Interaction Analysis system was considered. So, too, were Amidon and Hough's Observational System for the Analysis of Classroom Instruction, the Instrument for Analysis for Science Teaching, a long instrument consisting of 23 categories, Science Teaching Observational Instrument, a rather short 5-category system and, finally, the Activity Categories Instrument (ACI) developed by Caldwell.

The Activity Categories Instrument (ACI) was found to be the most appropriate instrument for the main study. It consists of eleven categories describing student-centred and teacher-centred activities.

Interaction Analysis - Activity Categories.

The ACI was constructed and validated at Syracuse University by H. E. Caldwell. The instrument has been used in over 300 schools in the United States. It has also been used for inservice training and supervision as well as preservice training in West Virginia and Syracuse Universities. It helps to determine the proportion of time spent on laboratory activities, questioning, and other aspects of classroom interaction. The modified ACI as used in this study appears on Fig. 5 of Appendix C.

Distribution of the Questionnaires

For the main study Surrey School District was selected. This school district, comprising 60 elementary schools, 9 junior secondary schools and 5 senior secondary schools is one of the largest school districts in the Greater Vancouver area. The district is of interest also in terms of the number of diverse communities.

After selecting the district a letter requesting permission to conduct the study was sent to the District Superintendent by the senior supervisor of this work. After permission was granted regular contact was maintained with the Supervisor of Intermediate Instruction. Through the office of the school district, with the help of the Supervisor for Intermediate Instruction, eighty questionnaires were distributed to seventh grade science teachers. Forty-five were returned, with one response incomplete since the teacher was no longer teaching science. This rather low return as compared to the preliminary study may be attributed to the time of the study. The preliminary study was conducted in summer and the results were not ready until the middle of fall. The effect on the main study was that the revised questionnaire was not ready until the middle of fall semester and distribution could only begin in the first week of December, which coincided with the heavy Christmas mails and activities. However, this could not be avoided due to the limited time available for this study.

Selecting the Sample for Observation

A stratified random sample of twenty seventh grade science teachers was selected from among the respondents to the questionnaire. Two later withdrew, leaving a sample of eighteen.

The analysis of responses to the questionnaire revealed that almost all the teachers depended on various curriculum units, especially, ESS and the Curriculum Guide (Science 7) (Table III), therefore it was possible to make random selection of teachers who used these units.

Equal numbers of experienced (those with more than three years experience) and less experienced teachers (those with less than three years science teaching experience) were selected to make the sample more

TABLE III

LEARNING RESOURCES USED BY TEACHERS

IN THE MAIN STUDY

Item	Average number of materials used	Number of users	Percentage
Learning Aids*	2.5	32	83
Curriculum Project Units**	1.7	42	97
B.C. Curriculum Guide. Science 7***		44	100

n = 44

* These included audio-visual materials, textbooks and fieldtrips.

** Units included were Experiences in Science (EIS), Elementary Science Study (ESS), Science - A Process Approach and Elementary School Science Project, University of Illinois (ESSP-ILL).

*** 84% of the subjects in the population used the Guide "moderately", while 14% used it "closely". Only one subject used it "sparingly".

representative. The criterion of experience was established in the earlier preliminary study (see page 5). To avoid observer bias the selection was made by the supervisor of Instruction (instead of the investigator himself). At the same time a fair distribution of the schools in the district was maintained. All the teachers selected were put on a common roll and details of their experience were not known until after the end of the observation of the classroom activities.

The distribution of elementary schools in the district as well as those in the sample is shown in Figure 3.

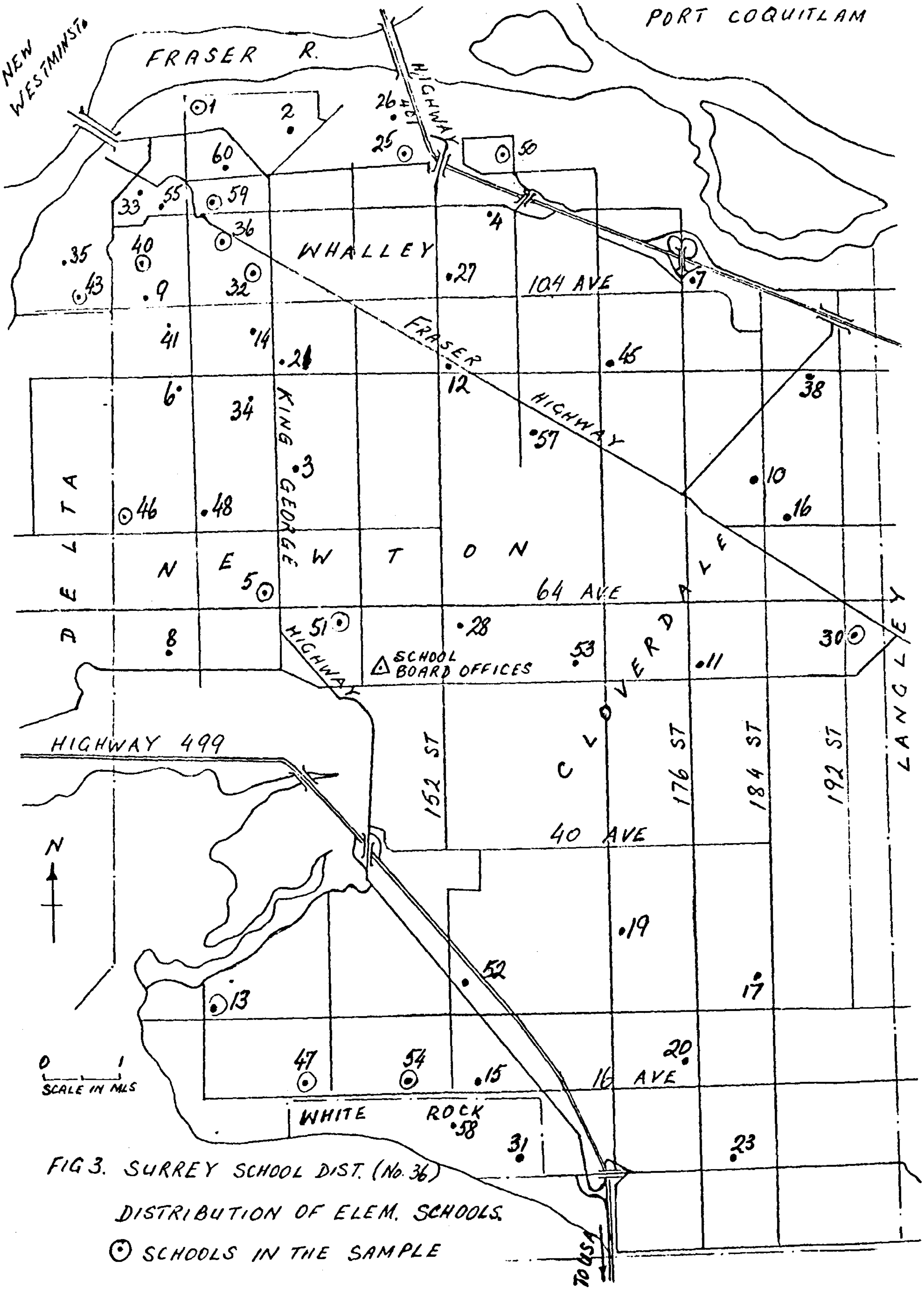

FIG 3. SURREY SCHOOL DIST. (No. 36)

DISTRIBUTION OF ELEM. SCHOOLS.

⊙ SCHOOLS IN THE SAMPLE

Types of Classrooms Visited

The typical science classroom was only slightly different from the ordinary classroom. Because of the use of packaged units that could be easily assembled before and packed after each lesson, some of these classes were held in a very "unscientific" environment. It was not uncommon to find slant-topped tables used for other subjects being used for science experiments such as balancing forces on beam balances. Some classes were held in special areas or rooms equipped with water taps. The classes that were held in special science classrooms providing appropriate environment for laboratory-type science lessons a accounted for about 50% of the classes visited.

Observation of Selected Science Classes

After selecting the sample, the teachers as well as their principals were informed about the study by the Supervisor of Intermediate Instruction, and permission was sought to visit the science classes of the Grade Seven teachers selected. Observations started in the second week of December and ended in the first week of March. With two exceptions each teacher was visited at least twice.

Systematic Coding of Classroom Interaction

Activities in the classrooms were recoded on "interaction analysis recording sheets"specially designed for this purpose. A sample recording sheet is shown in Table XV, Appendix C. The observer occupied a position (usually in the back of the classroom) where all activities were visible. At intervals of five seconds the number of the category in the Activity Categories Instrument that correctly described the behavior in the classroom was recorded. A short time, usually three minutes, was allowed by the observer for classroom "acclimatization" (i.e. getting acquainted with the general classroom atmosphere) before real coding started. The duration of lessons ranged from thirty minutes to one hour ten minutes. Pertinent remarks were made in spaces provided on the recording sheet and the records rechecked immediately after the lesson ended.

Beside the live coding a cassette tape recorder was used to record lessons for later coding. At least one lesson per teacher was recorded on tape. The recorded lessons were coded independently and the result compared with the live coding.

Ground Rules

In order to standardize the coding procedure a set of ground rules was established. These ground rules with minor modification (notably Rules 3 and 7) were similar to those suggested by Caldwell (1967) for the use of the Activity Categories Instrument. The ground rules as used in this study are summarized below:

1. A period of "acclimatization" of not more than five minutes is allowed by the observer before coding starts.

2. All coding begins and ends with Category 11.

3. When two activities of equal cognitive value occur simultaneously within a five second interval the observer records both events in the same space. For example, if a teacher asks a question (Category 7) while showing a filmstrip (Category 9), the observer records a 9^7, the base number denoting the sustained activity and the exponent the temporary activity.

4. When two or more activities occur sequentially within a five second interval, the observer records the activity that occupies the major portion.

5. Lulls during a lecture for purposes of note taking are recorded as 7, if they occur following a teacher question (Category 7).

6. When an interval cannot be assigned a number it is left blank and the situation explained in the "remark" column.

7. Student Talk occuring while students are working on an experiment is deregarded, if such talk has no cognitive value or is not directed to the entire class. For example, when students are working in groups on open-ended experiments (Category 1) and discussing among themselves, the observer records only open-ended experiment and comments in the remark column.

8. Guest speakers and any persons other than the members of the class are disregarded. The intervals such people occupy are indicated as interruption.

9.* In a split class all activities involving the class not under investigation are disregarded. (In this study Grade 6).

10.* Tests, fieldtrips and activities of substitute teachers are not coded.

Problems of Observation - Application of the Instrument

The main problems in a study of this kind relate to observer bias, observer reliability and observer consistency. Among the factors that contribute to these problems are instability of behavior and inconsistency in the items of the observation schedule. However, the second factor is corrected by the use of a validated instrument. To avoid observer bias in coding, care was taken to avoid subjective judgements. Inferences regarding the significance, value, or relationship of the set of behaviors to be coded were avoided. Beside this precaution, the record of teacher background was not referred to until after the completion of the observations.

To establish the validity of the results two factors were mathematically determined.

Consistency or Stability Coefficient. This is defined as the correlations between observations made by the same person at different

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* Rules 9 and 10 were added to suit the nature of the study.

times. In order to calculate this factor, randomly selected tape-recorded lessons were coded at intervals during the study, analysed, and the results correlated with results of the live coding. The Consistency Ratio calculated by Scott's method ranged from 83% to 87%, which shows adequate stability in coding. The Consistency Ratios are presented in Table IV.

Reliability Coefficient. Various approaches have been suggested for estimating inter-observer reliability (Medley and Mitzel, 1958). By far the simplest of these methods is that suggested by Scott (Flanders, 1960), which involves the calculation of a factor generally referred to as Scott's coefficient. The use of Scott's coefficient has some significant advantages.

1. It is not affected by low frequencies.
2. It can be adapted to percentage figures.
3. It can be estimated rapidly in the field.
4. It is more sensitive, particularly, at higher levels of reliability.

The coefficient (π) is expressed as the amount by which two observers (or observations) exceed chance agreement divided by the amount by which perfect agreement exceeded chance. Mathematically, it may be determined by formulae 1 and 2 below.

$$\pi = \frac{P_o - P_e}{1 - P_e} \qquad \ldots 1,$$

where,

P_o = the proportion of agreement, and

P_e = the proportion of agreement expected by chance. P_e is found by squaring the proportion of tallies in each category and

TABLE IV

ESTIMATED CONSISTENCY RATIOS

Instance	Consistency Ratio (Scott's Coefficient)
1st	0.87
2nd	0.85
3rd	0.89
4th	0.87

summing these over all categories, i.e.

$$P_e = \sum_{i=1}^{k} P_i^2 \qquad \ldots 2$$

where, P_i is the proportion of tallies falling into each category, and k is the number of categories.

To test for coding reliability, a series of observations were made simultaneously by the investigator and a second experienced observer. The results of both observers were analysed as in Table XVIII. Using the Scott method the level of reliability was computed as follows.

$$\pi = \frac{P_o - P_e}{100 - P_e}$$

$$= \frac{(100 - 12.7) - 24.88}{100 - 24.88}$$

$$= \frac{62.41}{75.72}$$

$$= 0.837$$

Thus,

$$\pi = 0.84$$

The Scott's coefficient computed in this manner indicated a level of agreement between 0.84 and 0.87. Flanders (1960) cites an acceptable level of 0.85 for such in-session coding.

Other Problems Involved in the Observation

Other problems encountered were of a practical nature. A study involving personal appearance in the classroom sometimes evokes a great deal of uneasiness among the subjects. This factor may lead to

TABLE V

ESTIMATED RELIABILITY COEFFICIENTS

Instance	Coefficient
1st	0.84
2nd	0.85
3rd	0.87
4th	0.84

noncooperation or outright refusal by the teacher to participate. One reason for such feeling is the fact that most classroom observations tend to be associated with teacher evaluation. Therefore, teachers in the sample were made aware in a cover letter, of the fact that the study was not for evaluative purposes or commissioned by the school district. Also, emphasis was laid on the class as a whole rather than on the teacher in particular.

It is commonly assumed that the appearance of a visitor in the classroom affects the normal classroom climate. This may be particularly so in this study since arrangements were made with the teacher prior to each visit. Ideally it would have been better to pay the visits unannounced to avoid "special lessons". However, this approach, besides being practically impossible would have been difficult to make without arousing suspicions about the objectives of the study. The disadvantage of the direct and formal approach was possibly counteracted by the willingness of the teachers in the sample to participate and the enthusiasm shown in the study.

Another means of overcoming the effect of observer presence would be to pay several visits to each teacher. In practical terms this was impossible because of the relatively large sample, the length of the visits, and the fact that most of the science lessons were scheduled at the same time. With few exceptions at least two visits were made to each class. These visits were scheduled, where possible, in such a way as to cover as many aspects of science teaching as possible. For example, if a session was mainly discussion the investigator tried to arrange the next visit to coincide with a lesson that involved more activity, if the unit being treated was designed to contain science activities. Despite all the constraints attempts were made to make the visits as informal as possible, care being taken not to disrupt the general course of events in the classroom.

CHAPTER IV

ANALYSIS OF THE DATA

Introduction

During observation of the lessons, two main types of lessons were encountered:

1. Some science lessons were centred around general student activities. These lessons consisted mainly of science units obtained from the district resource office. Invariably the units under treatment were those of the Elementary Science Study (ESS) project (Educational Services Incorporated, Newton, Mass.). Units being treated at the time of this investigation were "Bones" (5 lessons), "Gases and Airs" (4 lessons), "Kitchen Physics" (5 lessons), "Microgardening" (2 lessons) all from the ESS series and "Sound".

2. Some science lessons, though designed to arouse student interest, were by their nature highly teacher-centred and had very little laboratory content. Among the units used in these lessons were "Astronomy", "Time" and "Geologic Processes".

In accordance with the objectives of the study the lessons were classified into "activity-oriented" and "non-activity-oriented" for purposes of analysis. In one or two instances a unit that is activity-oriented in design was classified as non-activity-oriented because the class had a discussion of the unit during the entire science period, without any practical activity.

Composite Percentage Tallies of the Activity Categories

The composite percentage tallies show the percentage of total tallies in each category for the sample of teachers. These statistics give a rough idea of the classroom dynamics. The composite percentage tallies are obtained by summing up all tallies in each category over the whole period from the raw score from the observation schedules for individual teachers in the sample and computing the percentage for each category. Table VI shows the composite percentage tallies.

Categories 1 and 2 - "Open-ended" and "Structured" laboratory experiences were used, when the unit was activity-oriented, between 18% and 89% of the time with thirteen out of twenty five such lessons scoring above the 50% mark. Category 3 was not observed. Category 4, "Student Demonstration" was sparingly used - less than 2% of the time. Category 5 - "Student Reporting" - a group of students or individuals reporting on a project, library research, or an experiment done in class in which they are expected to make inferences or independent analysis was not observed a great deal - about 3% in three instances and over 10% on three other occasions.

Categories 6, 7 and 8 which express the measure of verbal interaction in the classroom were used a great deal in all the lessons. Category 6 - "Student Talk" was used between 3% and 40% of the time - with eight instances over 20% and eleven between 10% and 15%. Category 7 - "Teacher Questioning" was between 0% and 18% which breaks down to over 10% class time on ten occasions, 5% to 10% on ten occasions and less than 5% in seven other instances. Category 8, "Teacher Talk" was used between 6% and 50% - over 40% on four occasions, 20% to 40% on another four, 10% to 20% on ten and less than 5% class time on five other occasions. Category 9 - "Teacher Demonstration" was less used, in one instance for about 29% but generally between 1% and 5% when the unit was not activity-oriented.

TABLE VI

COMPOSITE PERCENTAGE TALLIES

IN EACH CATEGORY

Subject	Category										Title of unit	Nature of unit
	1 & 2	3	4	5	6	7	8	9	10	11		
1	-	-	0.4	10.7	10.7	6.5	24.4	43.9	-	3.4	Astronomy	NAO***
2	66.0*	-	-	-	3.0	1.0	26.0	3.0	-	1.0	Gases and Airs	AO***
	21.8*	-	-	-	14.9	11.9	19.6	31.6	-	1.1	Gases and Airs	AO
3	42.8	-	-	3.2	20.2	9.0	17.0	-	-	7.8	Kitchen Physics	AO
	35.0	-	-	-	25.0	15.0	15.0	1.0	-	9.0	Kitchen Physics	AO
4	43.2	-	0.4	-	10.2	3.9	17.7	16.1	-	8.5	Sound	AO
	29.6	-	2.3	-	35.2	16.6	10.7	-	-	5.6	Sound	AO
5	-	-	-	-	26.7	9.4	53.9	8.4	-	1.6	Astronomy	NAO
6**	-	-	-	-	12.3	8.7	40.5	4.1	33.8	0.5	Bones	NAO
	-	-	-	-	17.4	13.3	56.1	5.2	-	1.0	Bones	NAO
7	79.3	-	-	-	5.6	2.5	11.2	1.0	-	0.4	Kitchen Physics	AO
	78.9	-	0.2	-	4.9	5.5	9.3	0.4	0.4	0.4	Kitchen Physics	AO
8	34.8	-	0.8	-	15.2	9.7	35.6	1.4	-	2.6	Scale Drawing	AO
	24.2	-	2.8	-	20.5	18.6	30.6	4.4	-	2.7	Bones	AO
9	64.5	-	-	-	6.1	1.5	22.0	4.4	-	1.7	Gases and Airs	AO

* Each row represents one visit.
** Though the unit being treated in this lesson was activity-oriented, the lesson itself did not involve

TABLE VI (CONTD.)

Subject	Category 1 & 2	3	4	5	6	7	8	9	10	11	Title of unit	Nature of unit
10	89.1	-	-	-	3.2	-	6.8	-	-	0.9	Bones	AO
	19.6	-	-	-	14.9	5.9	53.1	2.2	-	4.4	Microgardening	AO
11	36.5	-	-	22.3	10.8	6.1	21.6	1.0	-	1.7	Gases and Airs	AO
	18.4	-	-	-	12.7	15.0	15.2	-	33.3	5.4	Gases and Airs	AO
12	70.0	-	-	-	3.8	4.2	18.6	-	-	6.3	Kitchen Physics	AO
	65.0	-	-	-	6.6	5.7	10.8	5.7	-	6.3	Kitchen Physics	AO
13	83.2	-	1.5	-	4.1	4.3	6.1	-	-	0.7	Bones	AO
	19.7	-	-	-	11.8	12.2	53.6	1.0	-	1.6	Kitchen Physics	AO
14	0.8	-	-	3.0	15.0	5.8	71.8	1.8	-	2.0	Time	NAO
	0.5	-	-	-	8.5	14.9	52.2	8.9	3.9	2.8	Time	NAO
15	66.4	-	1.9	3.6	11.5	6.0	9.1	0.6	-	1.0	Microgardening	AO
	0.4	-	-	12.5	41.1	17.7	25.1	-	0.4	2.8	Microgardening	AO
16	67.0	-	0.2	0.2	7.2	4.7	12.3	1.8	-	6.7	Gases and Airs	AO
	64.7	-	-	-	16.0	6.1	11.4	0.9	-	1.9	Gases and Airs	AO
17	-	-	0.3	-	19.4	9.2	52.1	17.0	-	2.0	Geologic Processes	NAO
	-	--	-	-	21.5	6.9	54.4	8.2	4.0	4.0	Geologic Processes	NAO
18	89.0	-	-	-	-	-	8.1	-	-	3.0	Bones	AO
	43.1	-	-	-	21.0	15.9	19.2	-	-	0.7	Kitchen Physics	AO

any laboratory activities, therefore for purposes of analysis it was classified as non-activity-oriented.

*** AO denotes activity-oriented while NAO non-activity-oriented lessons.

Category 10 - "Workbook Work", when students copy from chalk board or books or work on sheets, activities that demand very little independent thinking by the students, was observed on two occasions occupying less than 4% of the time, and on two other occasions for 33% of the time. Category 11 - "General Havoc", usually consisted of time spent setting up equipment, regrouping students, humour and prolonged laughter. This activity occupied between 1% and 8% of the time. Often the magnitude of this category was a measure of student activity in the classroom. It is interesting to note that the tallies in this category for the non-activity-oriented units were usually below the mean for the sample.

Interaction Matrix

The composite percentage tallies alone cannot describe classroom interaction or the nature of the strategy employed by the teacher. In order to determine some specific aspects of teaching behavior an interaction matrix was constructed as described in Chapter 3 (Methods and Procedure). A matrix for each individual subject was constructed from the raw scores. From these matrices ratios describing specific aspects of classroom interaction were calculated for each subject. These were the Activity Ratio, Laboratory Ratio and Questioning Ratio.

Activity Ratio. This ratio is indicative of the amount of student involvement with the process of learning in the science classroom. A high Activity Ratio indicates a more student-centred lesson or indirect teaching method.

The ratios were calculated from the column totals of the matrix for each subject. Thus, the Activity Ratio was determined by dividing the sum of total tallies in columns 1 to 6 (indirect activities) by those of columns 8 and 10 (direct activities). Mathematically, the Activity Ratio was stated as:

$$\text{A.R.} = \frac{\text{Sum of Column totals for columns 1 to 6}}{\text{Sum of Column totals for columns 8 to 10}}$$

Category 7 - "Teacher Questioning" was not considered in the calculation. However, this category influences the magnitude of the Activity Ratio. When there is a preponderance of teacher questioning the Activity Ratio is higher, since some of the "lecture" time is taken by questioning and therefore the denominator of the ratio is reduced. At the same time the numerator should increase (unless the questions were mostly rhetorical) because the questions, by eliciting student response, shift some of the tallies to Category 6 - "Student Talk", one of the categories that determine the magnitude of the numerator. An Activity Ratio greater than 1 can be considered significant (Caldwell, 1970). An Activity Ratio value of 1 or greater means the teacher employed more indirect than direct teaching strategy.

Column 1, Table XIX, Appendix C shows the Activity Ratio values for all the subjects in the study. In almost all cases where the units were activity-oriented the Activity Ratios were substantially greater than 1, ranging from 1.2. to 11.2.

Laboratory Ratio. This ratio reflects the proportion of class time during which students were actually taking part in laboratory experiences. In this study laboratory experiences implied students performing experiments simple or complex in order to discover, establish or understand a concept or phenomenon in science. Science laboratory experiences in the sample of classes visited consisted of activities such as observing and examining bones and building skeletons of animals from these bones, counting drops of water and measuring the height of the non-beaded part of a stream of water; constructing and using balances to discover the principles of forces; conducting simple experiments with candles to discover the properties of air gases.

The Laboratory Ratio was expressed as the proportion of time spent teaching science with laboratory activities. The ratio may be stated thus:

$$\text{L.R.} = \frac{\text{Sum of Column Totals of Columns 1 and 2}}{\text{Sum of Column Totals of Columns 1 to 10}}$$

The L.R. was high for activity-oriented lessons with a minimum value of 0.2 and maximum of 0.9. About half the lessons had L.R. greater than 0.5, i.e. 50% of class time was spent on laboratory activities. The L.R. values are shown in Column 2 of Table XIX, Appendix C.

Questioning Ratio. This is the proportion of teacher utterances in the form of questions. The ratio may be expressed as:

$$\text{Q.R.} = \frac{\text{Sum of Column Totals of Column 7}}{\text{Sum of Column Totals of Columns 7 and 8}}$$

The Q.R. ranged from 0 to 0.51. About two thirds of the scores fell within 0.2 and 0.4 range, i.e. in these cases 20% to 40% of teacher speech was in the form of questions. In a few cases (five activity-oriented lessons) the Q.R. was below 0.1. The Q.R. values are shown in Column 3 of Table XIX, Appendix C.

Composite Matrix

Composite or master matrix showing average percentage of total tallies in each cell of the individual matrices were constructed. The total of each column of the matrix (shown on page 67) indicates the average

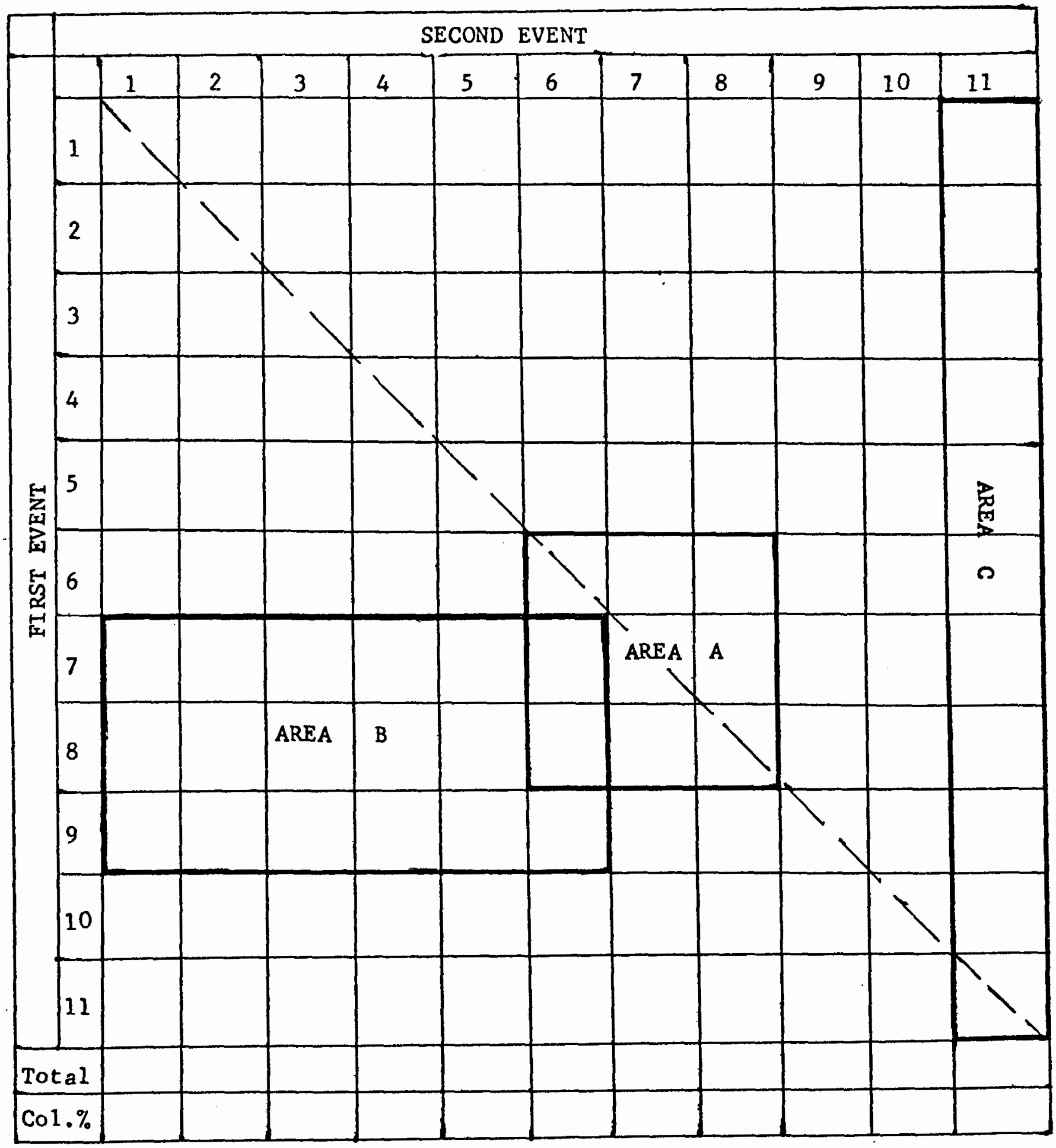

FIGURE 4

AREAS OF MATRIX
SHOWING PATTERNS OF INTERACTION

TABLE VII

COMPOSITE MATRIX

OF THE MEANS OF THE TALLIES

	SECOND EVENT											
FIRST EVENT		1	2	3	4	5	6	7	8	9	10	11	
	1												
	2		777.2		0.2	0.1	5.6	4.0	13.7	0.6	0.1	1.9	
	3		0.4										
	4		0.4		1.1	12.7	0.4	1.6	0.8				
	5		0.3		0.3	10.9	0.1	0.3	0.3				
	6		5.5		0.6	0.2	87.4	65.6	56.5	0.6	0.7	2.4	
	7		1.9		1.1	0.2	94.9	18.2	11.0	0.2		0.6	
	8		13.0		0.8	2.7	15.9	35.9	223.7	1.9	0.5	3.5	
	9		0.7		0.1		0.1	1.5	2.9	6.9	27.7		
	10		0.1				0.3	0.2	0.2		20.6		
	11		2.6			0.1	0.6	1.4	6.7		6.5	36.7	
Total			801.7		3.8	26.9	205.3	128.4	315.5	15.2	56.1	42.2	1595.1
Col.%			50.3		0.3	1.7	12.9	8.0	19.8	0.9	3.5	2.6	100

percentage of tallies recorded for that category and is a measure of the average percentage of time teachers in the sample used a particular category. Cells lying along the diagonal e.g. 1-1, 2-2, 3-3, 4-4, ..., 11-11 represent the average number of times that a category of behavior was sustained for periods longer than five seconds (Steady State). The other cells indicate the average number of times one category of behavior changed to another (Transitional Behavior). Figure 4 shows an interaction matrix with areas describing some patterns of interaction (Interaction Areas) of interest to this study.

Areas of Specific Interaction

Areas of interaction matrix which contain common elements were identified in the composite matrix for the analysis of some specific instructional behaviors. There are various ways of identifying these areas and using them to describe classroom behavior. These areas shown in Figure 4 were found relevant to the analysis of this work.

Area A - Discussion Area. Tallies in this area were analysed to determine the nature of teacher-student interaction during discussion. Of particular interest were the activities in the steady state - cells 6-6 and 8-8. These cells indicate Student Extended Talk (S.E.T.) - the time during which a student talks uniterrupted by the teacher, and Teacher Extended Talk (T.E.T.) - when a teacher lectures uninterrupted by other activities. The ratio in percentages of these as well as those of the transition behaviors were computed as a ratio of the sum of all the mean tallies in this area.

$$\text{Student Extended Talk (S.E.T.)} = \frac{\text{Mean tallies in cell 6-6}}{\text{Sum of mean tallies in area}} \times 100.$$

TABLE VIII

DISCUSSION AREA -

AREA A

Cat.	6	7	8	
6	87.4	65.6	56.5	
7	94.9	18.2	11.0	
8	15.9	35.9	223.7	
Tot.	198.2	119.7	231.2	549.1

$$\text{Student Extended Talk (S.E.T.)} = \frac{87.4}{549.1} \times 100$$

$$= 15.9$$

$$\text{Teacher Extended Talk (T.E.T)} = \frac{\text{Mean tallies in cell 8-8}}{\text{Sum of mean tallies in area}} \times 100$$

$$= \frac{223.7}{549.1} \times 100$$

$$= 40.6$$

Thus, S.E.T. = 16% and T.E.T. = 41%.

Transition Cells. By similar calculation transitional behaviors were determined. Student talk followed by teacher questioning (cell 6-7) was found to be 12%. Behavior in this cell may be interpreted as a teacher reinforcement or clarification of student statement. Student talk followed by teacher talk or teacher comment on student statement (cell 6-8) was 10%, while teacher question followed by student talk was 17.3%.

Area B - Student Reaction Area. Student responses to teacher behavior are indicated by this area. Tallies in these cells showed which student activity followed a teacher's question, talk or demonstration and other classroom activities. The analysis of this area (Table IX) indicated:

Very little teacher-student verbal communication during laboratory work. Teacher question followed by laboratory activities was almost negligible, while teacher talk followed by such activities was only 10%;

Teacher question followed by student response was generally the pattern of communication as shown by cell 7-6 (73% of the mean tallies);

TABLE IX

STUDENT REACTION AREA -

AREA B

Cat	1 & 2	3	4	5	6	
7	1.9	-	1.1	0.2	94.9	
8	13.0	-	0.8	2.7	15.9	
9	0.7	-	0.1	-	0.1	
Tot.	15.6	-	2.0	2.9	110.9	131.4

Teacher statements followed by student statements were also minimal (about 10%).

Area C. This area describes all activities followed by "general havoc" or confusion such as laughter, non-functional activity or noise. From the data in the composite matrix it can be seen that in a few cases this category of activity was followed by category 8 (Teacher Talk) with almost all the rest of the tallies in cell 11-11, showing extended "general havoc". This was characteristic of the science lessons, since normally class preparation for a laboratory was preceded by teacher directions.

A summary of the analyses is shown in Tables X to XII.

TABLE X

SUMMARY OF THE ANALYSIS

Category	Quantity
Total number of science lessons observed	33
Number of activity-oriented lessons	25
Number of non-activity-oriented lessons	8
Project units:	
Elementary Science Study (ESS)	27
Experiences in Science (EIS)	6

TABLE XI

SUMMARY OF THE ANALYSIS: COMPOSITE PERCENTAGE TALLIES - ROUGH DESCRIPTION OF CLASSROOM BEHAVIOR

Category	Min. Percentage class time	Max. Percentage class time
Laboratory Experiences	18	89
Student Demonstration	used only 2% of the time	
Student Talk	3	40
Teacher Questioning	0	18
Teacher Talk	6	50
Teacher Demonstration	1	5
Workbook Work	not used extensively	
General Havoc	1	8

TABLE XII

SUMMARY OF THE ANALYSIS:

INDICES OF TEACHING STRATEGIES

Ratio	Mean Value
Activity	4.36
Laboratory	0.55*
Questioning	0.32**
Student Extended Talk	16%
Teacher Extended Talk	41%

* Fraction of class time.

** Fraction of teacher utterances.

CHAPTER V

DISCUSSION OF THE RESULTS

Examination of the data from the preliminary study revealed no strong relationship between biographical and behavioral characteristics of the teachers in the sample with the possible exception of experience (length of time a teacher has been teaching science.). Further, comparison of the biographical and attitudinal characteristics of the sample in the preliminary study and that of the main study showed similar trends (Table XIII). On this basis the main study was defined as descriptive rather than comparative.

Both the preliminary and main questionnaire surveys indicated that the problems faced by teachers in teaching intermediate science were class size and control (including split classes) and lack of adequate facilities. Teachers did not perceive the lack of a strong science background or teaching experience as handicaps in teaching science at that level. However, a greater percentage of the teachers in the samples had adequate background (either science courses or science methods courses) in science. The use of newly developed science units especially those from Elementary Science Study (ESS) was high. Teachers perceived a moderate to high interest and achievement by the students in these units.

In discussing the results of this study, no value judgement on a behavior pattern will be attempted since the study was designed to be exploratory. The dichotomy of teaching strategies into "direct" and "indirect" does not bear any connotation of teacher effectiveness since no criterion of effectiveness was established.

TABLE XIII

GENERAL CHARACTERISTICS OF SUBJECTS

IN PRELIMINARY AND MAIN STUDIES

Academic and Professional Preparation	Raw Score		Per Cent Score	
	Prelim. Study	Main Study	Prelim. Study	Main Study
University degrees	25/30	33/44	83	75
Taken introductory science courses	26/30	31/44	86	71
Taken advanced science courses	16/30	12/44	54	27
Taken courses in science teaching methods	25/30	32/44	83	73
Acquired science teaching experience in university practicum	18/30	23/44	60	52

In describing the classroom climate of the teachers five indicators of instructional strategy were selected, i.e.

1. indirect or direct teaching method as described by the Activity Ratio;
2. student involvement in actual laboratory or practical activity as described by the Laboratory Ratio;
3. proportion of teacher statements in the form of questions;
4. extent to which students talked uninterrupted;
5. extent to which a teacher talked uninterrupted.

In addition to these strategies the situational feedback (in the form of comments in the questionnaire and during classroom observation) will also be discussed.

Activity Ratio

The extent of teacher indirectness as determined by the Activity Ratio for the activity-oriented lessons was marked. The Activity Ratio values ranging from 1.2 to 11.2 with modal score in the region of 3.5 and the mean of 4.6 was significant. The Activity Ratio was high when the Laboratory Ratio was high. On the other hand, considered in relation to other instructional strategies some of the ratios were gained at the expense of other interaction ratios, particularly the Questioning Ratio. In other words, the exhibition of significant measure of indirectness in this type of lessons may not be an end in itself. It raises the question of the level of teacher indirectness effective for the new approach to teaching intermediate science. Flanders and other researchers (1967, 1967a) pointed out that depending on certain situational factors the effectiveness of "Direct-Indirect" strategy will be a function of its variability. In some situations it will be desirable to vary the ID-ratio, in this case the Activity Ratio, from high to low or vice versa, in order

TABLE XIV

INTERACTION SCORES - BY SUBJECT MATTER

Unit	Teacher	Activity Ratio	Lab. Ratio	Question Ratio	S.E.T.*	T.E.T.*
Bones	8	1.89	0.25	0.39	8.1	46.0
	10	9.00	0.90	0	14.8	55.6
	13	11.20	0.78	0.38	0	46.7
	18	11.13	0.92	0	6.3	57.2
Gases and Airs	2	1.20	0.46	0.22	4.0	53.5
	2	1.93	0.55	0.29	0	49.6
	9	2.50	0.66	0.05	16.4	24.5
	11	5.10	0.37	0.20	9.4	45.0
	11	3.00	0.20	0.50	4.7	22.5
	16	5.58	0.71	0.23	22.6	30.6
	16	4.55	0.66	0.32	12.9	50.6
Kitchen Physics	3	3.74	0.47	0.35	20.1	18.5
	3	3.82	0.40	0.51	21.2	10.0
	7	8.15	0.81	0.21	16.7	48.6
	7	7.50	0.76	0.39	7.1	33.0
	12	4.35	0.75	0.17	0	58.5
	12	0.33	0.61	0.43	8.6	26.8
	13	1.77	0.45	0.29	7.2	43.4
	18	3.57	0.52	0.41	5.7	63.6
Microgardening	10	0.71	0.24	0.10	6.5	70.5
	15	7.0	0.64	0.40	20.9	17.0
	15	2.0	0.01	0.38	22.1	18.0
Scale Drawing	8	2.15	0.41	0.20	-	-
Sound	4	1.59	0.47	0.35	19.1	47.0
	4	4.29	0.30	0.52	47.6	22.0

*S.E.T. - Student extended talk, T.E.T. - Teacher extended talk. Scores in percentages.

to improve pupil achievement. Hamachek (1970) argued that classrooms in which achievements and attitudes were superior were likely to be conducted by teachers who did not blindly pursue a single behavioral-instructional approach to the exclusion of other possibilities.

The influence of subject matter on the teacher's use of strategy was quite discernible. All the high Activity Ratio scores - 9.0, 11.20 and 11.13 - were for the science lessons on bones. The influence of the subject matter is shown also by the fact that teachers who had high Activity Ratio scores in the lesson on bones had lower or average scores when treating other activity-oriented science units, i.e. A.R. = 0.71 for the "Microgardening" and 1.77 and 3.57 for the "Kitchen Physics" units. The question that arises from this influence of subject matter is whether or not consistent ratios are attainable and/or desirable. There is virtually no material concerning this aspect of classroom interaction in the literature reviewed. Moon (1971) studying classroom interaction of teachers using Science Curriculum Improvement Study materials and those using "textbook materials" conjectured that the type of science material might have an influence on the teacher's presentation. On the other hand Newport and McNeil (1970) in a study on Science - A Process Approach (SAPA), while not directly commenting on the effect of the material illustrate the difficulty which faces the teacher using the new programs in science without training. They concluded that without training the teachers "misuse" the SAPA units in such a way that instruction differs little from that of textbook teaching.

<u>Laboratory Ratio</u>

Laboratory Ratios were high. A ratio of 0.5 means 50% of class time was spent on science experiments by the students. On the average about half the class time was spent on experiments in the activity-oriented lessons. The category of Laboratory Experiences is one of the main determinants of the Activity Ratio, therefore where there were very high Activity Ratio values there were corresponding high Laboratory Ratio values. The highest values were for lessons on bones although these lessons had the lowest Questioning Ratio scores. In the other units, particularly "Gases and Airs" and "Kitchen Physics", the Laboratory Ratios were high and had corresponding though not very substantial Questioning Ratios. The effect of the Questioning Ratio is in the direction-giving by teachers. This means that the influence of the unit is its direction-giving potential. It seems that with the "Bones" unit there is little or no direction-giving by the teachers. The cognitive effect of the lack of direction-giving is not clear in this study. However, when the "discussion" is considered, the Student Extended Talk for the "Bones" unit falls below the mean and is heavily outweighed by the Teacher Extended Talk indicating minimal student verbal participation in the "Bones" unit. On the whole, when the lesson was highly laboratory-oriented, the proportion of time spent by the teachers in asking questions was very low.

Questioning Ratio

The Questioning Ratio was determined in relation to all teacher utterances over the whole lesson. In about 50% of the activity-oriented lessons observed the Questioning Ratio exceeded 30%, i.e. a third of teacher utterances were questions. However, it seems that most of these questions occured during the "discussion", as can be seen from Table IX. Teacher questioning followed directly by laboratory activities was negligible as were teacher statements followed by the same type of activities, i.e. teacher direction-giving was generally low.

Verbal Interaction

This aspect of classroom interaction was described by the "areas" of the matrix, particularly the "Discussion Area". Discussion in the context of this study was teacher-student verbal exchange over an extended period of one minute or more. This includes extended breaks in practical activities for purposes of explanation and other verbal behavior. The verbal interaction will be discussed in relationship to the general characteristics of behavior in the classroom.

Analysis of the raw observation scores revealed a general strategy of discussion and experimentation which may be schematically represented as follows:

Pre-experimental Discussion →	Experimentation →	Post-experimental Discussion
Introduction of the problem, statement of goals.		Examination of achievements and new concepts.

The analysis of the Discussion Area showed for pre- and post-experimental discussions a general dominance of teacher talk. Teachers talked uninterrupted for 41% (mean) of discussion time with a maximum of 70.5% and a minimum of 10%. Students talked individually or among themselves uninterrupted for 16% of the time on the average with a maximum score of 22.6% and a minimum of 0%. When a teacher was not lecturing he was directing students to talk. This is illustrated by the analysis of the transition cells of the Discussion Area of the matrix. On the average 49% of student statements were solicited by teacher questions and for 22% of discussion time a student's talk was followed by further teacher questioning or teacher comment. No allowance was made in the instrument to determine the nature of teacher-student verbal interactions. Since incorporation of more categories into the instrument would make it unwieldy and probably unworkable it would be advisable to use another cognitive observation system in conjunction with the present one if a more detailed and explicit study is attempted. Such a cognitive instrument could be used to determine if teacher questions and statements after student talk were aimed at reinforcement or clarification or just general direction-giving.

The experimental part of the science lessons hardly showed any major differences in the structure of science activities from classroom to classroom. The boundary between structured and unstructured laboratory experiences was rather blurred. Generally, experiments were structured in content and procedure. The heuristic exploration stage which characterizes the beginning of ESS units was not much in evidence. In many classrooms there was a great deal of uncontrolled movement when this mobility was permitted by the teacher. However, little of such movement was cognitively oriented and therefore could not be considered as charateristic of unstructured lessons, since even in such circumstances the assignments were, nonetheless, structured.

Teacher Feedback on the New Science Program

Teacher comments given in the questionnaire and during the classroom observation were noted. Opinions on the new science program did not vary greatly since all the teachers in the sample recognized the potential of the science units. While teachers were satisfied with the program generally, some were skeptical about sustaining interest in the units beyond the initial stage due to the fact that the units are ungraded and their use is determined by their availability. A typical teacher comment was:

> The main problem that I have noted with reference to interest in the units is that students have done bits and pieces of most of the available science

> kits, as well as the Grade Seven science text (dreadful as the latter is) in previous years.
> To my mind it would be more efficient if specific kits and activities were assigned to specific grade levels - thus avoiding duplication of material in succeeding years and the killing of a certain amount of enthusiasm.

The skepticism also covered the utility of the program. Grade Seven being the transition stage between the elementary and (junior) secondary school levels, some teachers felt that the objective should be to help the students to develop their methods of scientific investigation, "they should adopt a more serious outlook" with regard to science laboratory lessons to give them a foundation upon which further learning in the higher grades could be based. Some teachers felt that instead of this "serious outlook", students regarded the units as little more than children's games, and were afraid the objectives of the units would be lost through misinterpretation on the part of the students.

Another comment worth noting from the feedback is the problem of teaching split classes in a science setting that sometimes lacked adequate facilities and materials. This could be observed as creating problems in the teacher's span of attention. Though a fifty-fifty split of attention was generally reported, upon observation it was found that the teacher's attention was weighted in favour of one grade. In most cases the losers were the sixth graders*. One teacher in a split class situation put his problem thus:

> ... I am teaching a split class of sixes and sevens. Last year I taught a complete Grade Six class. Because I am faced with a new curriculum and at the same time trying to get the bugs out of the handling of the Grade Six program, I really feel that I cannot do justice to the excellent science program provided by the district.

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* It is possible that the investigators presence contributed to this imbalance.

The effect of the split class situation on the students is difficult to predict from this study.* But, as some teachers pointed out, if it is true that familiarity with the units reduces the interest of the students, then it may be argued that the split class situation would tend subsequently to reduce the interest of the sixth graders, who by sharing the same classroom environment with the seventh graders would have had a vicarious experience with the units before they treated them experimentally in subsequent years. Furthermore, it could reduce the problem-solving or inquiry potential of the units, since students would tend to know the products of their experiments beforehand.

Some Implications and Suggestions for Future Study

It was evident from this study that the teachers utilize to a significant degree the "indirect" method of teaching activity-oriented science lessons. However, the effectiveness of the indirect method as a teaching strategy could not be ascertained. Gage (1965) in a review cites indirectness as one of the "global characteristics" of effective teaching. While indirectness or student-centredness may be regarded as a criterion of effectiveness, other researchers have pointed out its dangers when used indiscriminately. The cognitive level of teacher-student discourse also was not determined. Therefore it can be concluded that the study served as a description of classroom interaction process defining a direction for a more explicit research design. Specifically, using a criterion for determining student achievement and more than

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* Since the investigator was mainly interested in the seventh grade, teachers might have, obligingly, focused their attention on the seventh grade.

one cognitive system of observation a relationship between student achievement and particular teaching strategies could be established. Some factors to consider in such a design would be:

1. size of the sample,
2. number of visits,
3. type of lessons (or units)
4. differences in the teachers' natural teaching style.

A smaller sample would make it possible to increase the number of visits, thereby improving between class and between visits reliability.

The effect of the material on the teacher's presentation is also worth consideration. In any in-service situation, it seems necessary to determine the relative theoretical and experimental (or practical) treatment of the units. If the difference in the teachers' treatment of the materials is attributable to misrepresentation of the objectives of the individual units, then, perhaps the training of prospective teachers (and possibly those in service) in the use of systematic observation for purposes of obtaining feedback in certain dimensions of classroom teaching would be worthwhile. Such training would enable the teachers to eliminate discrepancies in their perception and treatment of the various units. A teacher could tape and construct a simple category system in accordance with the objectives set for the project units. Analysis of his taped lesson could determine the cognitive level of classroom discourse.

Based on feedback from teachers some assumptions were made regarding the effect of split classes on the teacher and the lower grade pupils in such a situation, where the new science is concerned. Without an appropriate study the effect of such situational factors on the learning outcome of the lower grade pupils cannot be wholly ascertained. An investigation into the relationship of this factor to teaching and learning of the new science units might prove to be of some value.

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APPENDIX A

WILKES COLLEGE
WILKES-BARRE
PENNSYLVANIA 18703

November 1, 1971

Mr. Richard Abrokwa-Ampadu
Professional Development Center
Simon Fraser University
Burnaby 2, British Columbia

Dear Mr. Abrokwa-Ampadu:

I would be very happy to grant you permission to use my instrument, Activity Categories, in your research project. In return would you send me a report of your work when it is completed.

I am sending a copy of my report to the Department of Health, Education and Welfare for project #6-8760, as well as miscellaneous papers related to the instrument. Everything except the report of project #6-8760 is yours to keep or file, as you see fit. Unfortunately, this copy of the report is my only copy and I would like to have it returned when you are finished using it. Thank you.

If I can be of any further service, please do not hesitate to contact me.

Sincerely,

Harrie E. Caldwell
Associate Professor
Education Department

Enclosures

SIMON FRASER UNIVERSITY

FACULTY OF EDUCATION
OFFICE OF THE DEAN

BURNABY 2, BRITISH COLUMBIA
Telephone 291-3363 Area Code 604

23rd November, 1971

Mr. Earl Marriott,
District Superintendent of Schools,
School District #36,
14225 - 56th Avenue,
Surrey, B.C.

Dear Mr. Marriott,

I am writing on behalf of Mr. Richard Ampadu, a graduate student in this Faculty who is studying Science Curriculum and Instruction.

Mr. Ampadu is originally from Ghana. He holds a European Master of Science Degree and has come to Canada to study curriculum development. During his time at Simon Fraser University he has become interested in teaching strategies and particularly in the proportion of time given to various aspects of science instruction in the upper elementary school.

Specifically, Mr. Ampadu is interested in systematically observing seventh grade science classes. May I ask your authorization for him to conduct his study in the Surrey School District. Mr. Lintott, your intermediate supervisor, assures me that he will be willing to cooperate with Mr. Ampadu in making appropriate arrangements.

It is customary in such studies that the results be made available to personnel participating in the study and to the school district. We certainly anticipate making the study available through you.

Thank you for your consideration.

Yours sincerely,

Daniel R. Birch
Acting Dean
Faculty of Education

DRB:caa

Dictated by Dr. Birch and signed in his absence

APPENDIX B.

SIMON FRASER UNIVERSITY

Professional Development
Centre

Burnaby 2, B. C.
November 23, 1971.

Dear Science Teacher,

I am a candidate for the M.Sc. (Ed.) degree at Simon Fraser University. As part of a study being conducted into science education in the elementary school, the enclosed questionnaire is being distributed to Grade Seven science teachers in this school district with the kind permission of the authorities of the district.

The study is in two parts - the first part being the questionnaire. The second part will be a systematic direct observation of a number of Grade Seven science lessons randomly selected from all Grade Seven classes in the district. This will be taken in the early part of December. At least two visits per class will be made and classroom activities coded using a system called the Activity Categories Instrument (ACI). This is a modification of Flanders' System of Interaction Analysis which has been used extensively in research and in-service training, mostly in the field of social studies.

It is hoped that this study will reveal some of the general characteristics in the teaching of new and recently developed science units and packages, and possibly problems inherent in the new science curricula.

Material collected through either method will be treated in a highly confidential manner. No person other than the researcher will have access to any part of the data collected.

A report of this study when completed, will be made available to interested participants through the district offices.

Please fill in the questionnaire at your earliest convenience and return it in the envelope provided. In case your class falls in the selected sample, please treat it as an ordinary matter.

Your cooperation will be highly appreciated.

Thank you very much in anticipation;

Sincerely yours,

Richard Ampadu.

RA/eo

A QUESTIONNAIRE TO SEVENTH GRADE SCIENCE
TEACHERS OF SURREY SCHOOL DISTRICT (No. 36)

PROVINCE OF BRITISH COLUMBIA

Since this is a general study, it will not be necessary to attach your name to the questionnaire. In responding to the questionnaire, please feel free to add any comments you deem necessary.

Please, check on dotted lines where provided.

1. SEX. Male........ Female........

ACADEMIC AND PROFESSIONAL PREPARATION

2. Certificate held/salary scale.

EA/3........ PC/4........ PB/5........ PA/6........ Other........

3. Degrees held

B.A. .... B.Sc. ...... B.Ed. ...... BA./B.Sc. + B.Ed. ....

Other.......

4. Number of introductory science courses taken.

1........... 2........... 3.......... 4......... 5 or more.......

5. Number of advanced science courses taken.

1........... 2........... 3.......... 4......... 5 or more.......

6, Science methods course or curriculum seminar:

Yes........ No..........

7. Science teaching experience in university practicum:

Yes........ No..........

8. Number of in-service non-credit workshops.

1....... 2....... 3....... 4....... 5 or more........

PROFESSIONAL LEADERSHIP

9. Member of Science PSA. Yes........ No........

10. Served on curriculum revision or in-service education committee in science:

Yes........ No.........

PROFESSIONAL EXPERIENCE

11. Years of teaching........ (Please state)

12. Years of teaching science........

13. Years of teaching science in elementary school.................

14. Years of teaching science in the present district..............

15. Years of teaching science in the present school.................

TEACHING ASSIGNMENT

16. I am a) full time science teacher (science only)..............
b) full time teacher (science and other subjects)........
c) teaching principal........
d) teaching vice-principal........
e) teacher-librarian..........
f) teacher-counsellor.........
g) teacher with other duties (other than classroom teaching).......
h) part-time relieving teacher........

17. Percentage of school time I spend on teaching.........

18. My other duties (if any, other than teaching) affect my teaching activities.
a) a great deal........
b) just a little.......
c) not at all..........

19. I teach grade (s) 1-3....... 4-5....... 6....... 7.......
(Please, indicate percentage of time spent in each grade)

20. I teach science in grade (s) 1-3....... 4-5....... 6....... 7.......
(Please, indicate percentage of science teaching time you spend in the grade).

21. Besides science I teach 1..... 2..... 3..... more..... other subjects.
Please state the percentage of total science teaching time you give to the following methods of instruction.

22. Individualized instruction.........

23. Small group instruction.........

24. Class-size instruction........

25. Larger group instruction (more than one class).............

26. Please state the percentage of class time of Grade Seven science you spend on activity-oriented (and/or laboratory) lessons........

NATURE OF SCHOOL

27. I teach in a) open-area school..........
b) conventional school.......
c) other.........

CURRICULUM RESOURCES

28. My science 7 follows the Department of Education curriculum guide

a) closely .... b) moderately .... c) not at all ....

29. I find the material in the curriculum guide

a) too extensive .... b) adequate .... c) not extensive enough ....

30. In my opinion the Science 7 programme (as outlined in the guide) generates

a) above average pupil interest .... b) moderate pupil interest... c) below average pupil interest......

I regularly use for my instruction

31. Motion pictures films.........

32. Slides and/or filmstrips and/or filmloops...........

33. Fieldtrips...............

34. Teacher-prepared experiments.............

35. Audio-materials...............

36. Text-books.............

37. Commercial TV...........

38. Closed circuit TV or video tapes..............

I use experimental units from the project(s)

39. Experiences in Science (EIS) ....

40. Elementary Science Study (ESS) ....

41. Elementary School Science Project, Univ. of Illinois (ESSP-ILL).........

42. Science Curriculum Improvement Study (SCIS)..............

43. Science - A Process Approach. (AAAS)..............

44. Other...................

45. My greatest difficulty in using a laboratory or activity approach is

lack of laboratory facilities..............
lack of materials................
class size or control..........
my own lack of training and experience............
my own duties other than teaching...........

46. All the pupils in my class keep lab. records. Yes...... No......

47. I find it more convenient to correct the lab. records

in the classroom....... out of the classroom.........

PUPIL INTEREST AND ACHIEVEMENT

48. Pupils in my school have facilities (eg. Science Club) for extra-curricular science activities. Yes....... No.........

49. All the Grade Seven pupils..................)
Most of the Grade Seven pupils..............) participate(s) in
Some of the Grade Seven pupils..............) extra-curricular
None of the Grade Seven pupils..............) science activities.

50. The general performance of the Grade Seven science class is

above average.......... average.......... below average..........

51. The interest in science of the Grade Seven class in relation to other class(es) I teach (if any) is

above average........... average........ below average..........

52. The interest of the Grade Seven pupils in science as compared to their interest in other subjects (if any) I teach in this class is

above average......... average......... below average............

THANK YOU VERY MUCH FOR YOUR COOPERATION

APPENDIX C

Group	No.	Activity	Description
INDIRECT ACTIVITIES	1.	LABORATORY EXPERIENCE: OPENENDED	Students are presented a problem to be solved by experimentation. The procedure may or may not be given. They are required to make observations and analyse or interpret their findings.
	2.	LABORATORY EXPERIENCES: STRUCTURED	Students are presented a laboratory experiment with a structured procedure. They are not required to analyse or interpret their data. They are asked to make observations.
	3.	GROUP PROJECTS	One or more groups of students are working on a science project during the class period. Some may work individually, (not written projects).
	4.	STUDENT DEMONSTRATIONS	A student or group of students demonstrate a science experiment or project which they prepared. (Oral report on science project would be included).
	5.	STUDENT LIBRARY RESEARCH, REPORTING, ETC.	a) A student or group of students give an oral report they have prepared based on reference material. b) The class works with reference materials for purposes of writing or making reports.
	6.	STUDENT SPEAKING	The student contributes verbally by asking questions, answering a question or simply volunteering information.
	7.	TEACHER QUESTIONING	Students are asked a question by the teacher.
DIRECT ACTIVITIES	8.	LECTURE	The teacher reads aloud, expresses his views, gives directions, makes an assignment or asks rhetorical questions. Students are expected to listen. They may interrupt only when they do not understand. Student reading in the text is also included.
	9.	TEACHER DEMONSTRATION	The teacher presents materials by film, filmstrip, record, TV, radio, demonstration, etc.
	10.	WORKBOOK WORK	Students work in class on workbooks, homework, questions from texts, art-type work etc.
	11.	GENERAL HAVOC	The class may be cleaning up, settling down or doing nothing. In general, this category should be used sparingly.

FIGURE 5

REVISED ACTIVITY CATEGORIES INSTRUMENT

TABLE XV

SAMPLE RECORD SHEET

INTERACTION ANALYSIS - ACI SYSTEM

School No. ______________ Science Topic. ______________

Time: Sub-topics ______________

Start of lesson. __________ ______________

End of lesson. __________

Trial No. __________ Observer. ______________

Date:

Category numbers per period of 5 seconds												Notes or Remarks	Total tallies/minute										
11	8	6	6	7	6	7	6	7	6	8	7							6	5	1			1
6	8	7	6	7	6	7	6	7	6	8	8	Discussion 2 min.						5	4	3			
6	8	8	7	6	8	9	8	8	8	8	11	Description of						2	1	7	1		1
11	11	8	8	8	9	9	8	2	2	2	2	expt. to be done		4						4	2		2
2	2	2	2	2	2	2	2	2	2	2	2			12									
2	2	2	2	2	2	2	2	2	2	2	2			12									
2	2	2	2	2	2	2	2	2	2	2	2			12									
2	2	2	2	2	2	2	2	2	2	2	2			12									
2	2	2	2	2	2	2	2	2	2	2	2	Candles and peg		12									
2	2	2	2	2	2	2	2	2	2	2	2	One candle, 2, 3		12									
2	2	2	2	2	2	2	2	2	2	2	2	4 candles		12									
2	2	2	2	2	2	2	2	2	2	2	2	Concept - const.		12									
2	2	2	2	2	2	2	2	2	2	2	2	of O_2 in air.		12									
2	2	2	2	2	2	2	2	2	2	2	2			12									
2	2	8	8	8	11	8	7	6	6	6	8			2				3	1	5			1
6	6	7	6	8	7	6	8	8	7	6	6							6	3	3			
8	2	2	2	2	2	2	2	2	2	2	2			11						1			
2	2	2	2	2	2	2	2	2	2	2	8	Concept of gas		12									
8	8	7	6	7	6	8	7	6	7	6	6	pressure developed						5	4	3			
11	5	5	5	5	5	5	5	5	5	5	5	through expt.					11						1
5	5	5	5	5	5	5	5	5	5	5	5	Writing reports					12						
5	5	5	5	5	5	5	5	6	8	7	6	on proj.					8	2	1				
8	6	8	5	5	5	5	5	5	6	5	5	Results of expt.					8	2		2			
5	5	5	5	5	5	5	5	5	5	5	5						12						
5	5	5	5	5	5	5	5	5	5	5	5						12						
												Total Tallies		148			63	31	20	31	3		6

TABLE XV (CONTD.)

School No. __________

Category Numbers												Remarks											
5	5	5	5	5	5	5	5	5	5	5	5							12					
5	5	5	5	5	5	5	5	5	5	5	5							12					
5	5	5	5	8	6	7	6	6	6	6	6							4	6	2	1		
6	6	8	7	6	6	8	8	8	7	8	8	Instructions on							4	2	6		
8	8	8	8	8	8	8	8	8	8	8	8	next expt.									12		
8	8	8	8	8	8	8	8	8	8	8	8	Use of concept of									12		
8	8	7	6	8	8	8	8	8	8	8	8	expansion & contr.							1	1	10		
8	8	8	8	8	8	8	8	8	8	8	8	The case of the									12		
8	6	8	8	8	6	8	8	11				hard boiled egg.							2		6		
												Total						28	13	5	58		

Total Tallies over whole	1	2	3	4	5	6	7	8	9	10	11
		149			91	44	25	88	4		7
		36.52			22.3	10.78	6.13	21.57	0.98		1.72

TABLE XVI

SAMPLE MATRIX

Teacher No. 1

School No. 12

Trial No. 2

FIRST EVENT \ SECOND EVENT	1	2	3	4	5	6	7	8	9	10	11	
1												
2		147					1	2	1			
3												
4												
5					89	2	1					
6					1	14	9	18			1	
7		1				22		1				
8		2			1	7	11	67	2		3	
9		1						2	1			
10												
11					1		1	2			2	
Total		151			92	45	23	92	4		6	407
Col.%		37.0			22.6	11.1	5.6	22.6	1.0			99.9

Activity Ratio

Total Cat. 1 to 6 = 288

Total Cat. 8 to 10 = 96

$$A.R. = \frac{288}{96} = 3\cdot0$$

Lab. Ratio

Total Cat. 1 and 2 = 151

Total all Cat. = 407

(Incl. Cat. 11) 413

$$L.R. = \frac{151}{407} = 0.37$$

Questioning Ratio

Total Cat. 7 and 8 = 115

Cat. 7 = 23

$$Q.R. = \frac{23}{115} = 0.2$$

TABLE XVII

CALCULATING CONSISTENCY RATIO

BY SCOTT'S METHOD

Category	Live*	Tape*	Per Cent of (1)	Per Cent of (2)	Per Cent Diff.	(Average)^2
	(1)	(2)	(3)	(4)	(5)	(6)
1	-	-	-	-	-	-
2	79	68	18.4	15.2	3.2	2.81
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	60	71	14.0	15.9	1.9	2.23
7	66	76	15.4	17.0	1.6	2.62
8	147	140	34.2	31.3	2.9	10.00
9	-	-	-	-	-	-
10	78	92	18.2	20.6	2.4	3.75
Total	430	447	100.2	100.0	12.0	21.41

* Data from coding lessons directly in the classroom - (1), and from coding tape recorded lessons - (2).

TABLE XVIII

ESTIMATING RELIABILITY COEFFICIENT

BY SCOTT'S METHOD

Category	Observer A	Observer B	Per Cent of (1)	Per Cent of (2)	Per Cent Diff.	$(Average)^2$
	(1)	(2)	(3)	(4)	(5)	(6)
1	-	-	-	-	-	-
2	-	2	-	0.44	0.44	0.005
3	37	26	8.40	5.65	2.75	0.049
4	-	-	-	-	-	-
5	63	57	14.30	12.40	1.90	1.780
6	162	187	36.80	40.70	3.90	15.000
7	71	80	16.15	17.40	1.25	2.830
8	98	107	22.30	23.20	0.90	5.200
9	-	-	-	-	-	-
10	9	2	2.02	0.44	1.57	0.015
Total	440	461	99.97	100.23	12.71	24.879

TABLE XIX

INTERACTION RATIOS

SUBJECTS	ACTIVITY RATIO	LABORATORY RATIO	QUESTIONING RATIO	NATURE OF LESSON
1	0.42	0.00	0.20	NAO*
2	1.20*	0.46	0.22	AO*
	1.93	0.55	0.29	AO
3	3.74	0.47	0.35	AO
	3.82	0.40	0.51	AO
4	1.59	0.47	0.35	AO
	4.29	0.30	0.52	AO
5	0.45	0.00	0.09	NAO
6	0.12	0.00	0.11	NAO
	0.13	0.00	0.16	NAO
7	8.15	0.81	0.21	AO
	7.50	0.76	0.39	AO
8	2.15	0.41	0.20	AO
	1.89	0.25	0.39	AO
9	2.50	0.64	0.05	AO

*AO denotes Activity-Oriented, while NAO Non-Activity-Oriented lessons

TABLE XIX (CONTD.)

SUBJECTS	ACTIVITY RATIO	LABORATORY RATIO	QUESTIONING RATIO	NATURE OF LESSON
10	9.00	0.90	0.00	AO
	0.71	0.24	0.10	AO
11	5.10	0.37	0.20	AO
	3.00	0.20	0.50	AO
12	4.35	0.75	0.17	AO
	0.33	0.61	0.43	AO
13	11.20	0.78	0.38	AO
	1.77	0.45	0.29	AO
14	0.24	0.01	0.07	NAO
	0.16	0.01	0.20	NAO
15	7.00	0.64	0.40	AO
	2.00	0.01	0.38	AO
16	5.58	0.71	0.23	AO
	4.55	0.66	0.32	AO
17	0.36	0.00	0.18	NAO
	0.32	0.00	0.11	NAO
18	11.13	0.92	0.00	AO
	3.57	0.52	0.41	AO

TABLE XX

RATIO OF EXTENDED STUDENT AND TEACHER TALK IN THE PROCESS OF DISCUSSION OF TEACHER-STUDENT VERBAL INTERACTION.

SUBJECTS	RATIO IN PERCENT OF STUDENT TALK	RATIO IN PERCENT OF TEACHER TALK	NATURE OF LESSON
1	14.1	48.5	NAO
2	4.0	53.5	AO
	0.0	49.6	AO
3	20.1	18.5	AO
	21.2	10.0	AO
4	19.1	47.0	AO
	47.6	22.0	AO
5	11.4	43.8	NAO
6	4.6	75.5	NAO
	5.1	68.0	NAO
7	16.7	48.6	AO
	7.1	33.0	AO
8	6.1	29.5	AO
	8.1	46.0	AO
9	5.7	63.6	AO

TABLE XX (CONTD.)

SUBJECTS	RATIO IN PERCENT OF STUDENT TALK	RATIO IN PERCENT OF TEACHER TALK	NATURE OF LESSON
10	14.8	55.6	AO *
	6.5	70.5	AO
11	9.4	45.0	AO
	4.7	22.5	AO
12	0.0	58.5	AO
	8.6	26.8	AO
13	0.0	46.7	AO
	7.2	43.4	AO
14	7.0	69.3	NAO *
	2.7	64.5	NAO
15	20.9	17.0	AO
	22.1	18.0	AO
16	22.6	30.6	AO
	12.9	50.6	AO
17	8.2	54.0	NAO
	29.1	16.3	NAO
18	16.4	24.5	AO
	6.3	57.2	AO

* AO denotes Activity-oriented, while NAO non-activity oriented lessons.

APPENDIX D

Gr. 7

THE "CLOSED END" EXPERIMENT

Materials for two students

1 large plastic tube
candles, matches, and clay
red plastic cap

Background

In the first three experiments and we have been concerned with expansion and contraction of gases when temperature changes. The sucking down of the rubber sheeting, as well as the bulging out, suggests that gases which are contracting or expanding are able to exert a force of some kind to cause the rubber sheeting to stretch.

Method

Set up this experiment in the same manner as the previous ones. The only difference is that a red rubber cap will be substituted for the rubber sheeting.

Observations

1. What happens when the tube was placed over the candle?

2. How do you explain the results of this experiment?

3. Does it work every time? If not, why?

4. Try the experiment with two candles. Are the results the same? Why?

Summary

1. Summarize the experiments by telling what effect was noted by each of the following experiments.

   a. The "Open End" Experiment.

   b. The "Drumhead" Experiment.

   c. The "Closed End" Experiment.

....

The following experiments are designed to provide some observation for you to think about. How do each of them show the presence of air?

1. What's Pushing What?

Pull out the plunger on a 30-cc syringe pump to about the 15-cc mark, then dip the end of the syringe into some colored water. Withdraw the plunger to the 30-cc line. Hold the syringe-pump above a jar and push the plunger down.

2. Syringe-pump Under Water

Take a syringe-pump full of air and place the end of the syringe-pump under water. Push the plunger into the syringe-pump.

3. Sponge Under Water

Fill a jar almost full of water and squeeze a sponge under the water.

ADDITIONAL EXPERIMENTS WITH GAS PRESSURE

1. Changing Pressure By Chemical Means

Fill a tube partially with water and set it in a tray. Place rubber sheeting over the top. A seltzer tablet is placed on a piece of clay which is attached to the side of a large plastic tube. When the tube is sitting in the water, knock the tablet off into the water and observe the results.

2. A piece of wet steel wool is put into a tube and the open end is sealed off with rubber sheeting. Observe the results.

THE EGG AND THE BOTTLE

Materials

1/2 gallon milk bottle
1 hard-boiled egg (with shell removed) that will fit in the mouth of the bottle without falling into the bottle
piece of paper
matches

Method

The piece of paper is ignited and dropped into the milk bottle. The egg is placed over the mouth of the bottle as quickly as possible.

Think of a way to preserve what has happened.