BEHAVIOUR PATTERN OF A SCIENCE TEACHER IN TEACHING THE NATURE OF SCIENCE

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A B S T R A C T

BEHAVIOUR PATTERN OF A SCIENCE TEACHER IN TEACHING THE NATURE OF SCIENCE

The general focus of the study was to describe the behaviour patterns used by a science teacher in his normal teaching that contribute to the teaching of science and to develop hypotheses about some of the factors contributing to these behaviours. The specific questions posed in this study were:

1. Over a period of time, what behaviour patterns does a science teacher use in his normal teaching in different classroom settings that contribute to the teaching of the nature of science?

2. What are some of the variables underlying any observed behaviour pattern within each setting over the period of the study?

3. Which classroom settings does the teacher make the most use of for teaching the nature of science?

The patterns (both general and situation specific) of the teacher's behaviour were determined through an analysis of verbal and non-verbal behaviour using a modification of the Classroom Observation Instrument developed for the Earth Science Curriculum Project. This instrument defines four classroom settings, namely, the developing text material setting, the pre-lab setting, the laboratory setting and the post-lab discussion.

Data on the factors contributing to these patterns were collected through a formal pre-study interview and through daily observation of the classroom and discussion with the teacher. In particular data were collected on the teacher's intents, the teacher's perception of his students, availability of materials, the topics for the lessons, etc. In addition, data were collected on other factors which emerged during the observation and discussions with the teacher.

One major conclusion of the study was that the teacher used both general (or recurrent) behaviours and situation specific behaviours in each classroom setting during the three-week study. Some of the general behaviours observed in the different classroom settings were as follows:

During the developing text material setting, students were observed to participate in the lessons only through responding to the teacher's questions and there was a neglect of the philosophical limitations of science.

In the pre-lab, students were never observed to identify and state the problem or hypothesis for investigation.

During the lab sessions, the students were observed to ask questions and contribute ideas while the teacher moved around the groups asking questions and giving direct

answers to students' questions.

During the post-lab discussion, apart from drawing conclusions and predictions, students were not observed to communicate with other students or to provide critical and speculative analysis of their data.

The findings were found to reflect such interactive factors as (1) the prescriptive structure of the text, (2) the topics for the lessons, (3) the duration of the lessons, (4) the teacher's perception of the students, (5) the pressure to complete the topics in the limited time available, and (6) the teacher's approach which reflected the structure of the text, the duration of the lessons and the pressure to complete the topics in a limited time.

An analysis of the data, indicated that the teacher used the laboratory setting most and the pre-lab least for teaching the nature of science.

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CHAPTER ONE

THE RESEARCH PROBLEM

1.00 THE SCOPE OF THE STUDY

Recent curricular innovations such as PSSC Physics and Project Physics seem to emphasize the nature of scientific inquiry or the "way of the scientist" (Commission on College Physics, 1972). It is therefore important to study how the science teacher using such curricular materials will behave. Such studies have already been carried out by a number of researchers such as Evans (1969), Gallagher, (1970), Hunter (1969), Moon (1971), Parakh (1969) and Tisher and Power (1975) but the findings are conflicting. For example, Evans (1969) reported that teachers using the BSCS curricular materials did not differ significantly from teachers using non-BSCS materials in terms of such behaviours as the development of scientific processes (e.g. observation, interpretation), "content development" or the time devoted to "management" activities.

However, Moon (1971) noted that teachers using the Science Curriculum Improvement Study (SCIS) materials showed highly significant differences from "traditional teachers" by demonstrating greater preference for high level questions and by increasing the amount of the teacher's verbal

influence during the students' activities. Likewise, Lashier and Nieft (1975) reported some significant differences between teachers using the Intermediate Science Curriculum Study (ISCS) materials and those using non-ISCS materials. The ISCS teachers were found to play a less dominant role and their classrooms were characterised by high levels of student activity. In a study by Gallagher (1970) involving six competent biology teachers teaching the same topics from the BSCS curriculum, the teachers were found to vary in the strategies used in presenting the concepts. The diversity was noted in their instructional goals, level of conceptualization, manner of initiation of the topics, actual ideas discussed, the sequence of ideas covered and additional ideas included. Thus it's not clear whether the use of innovative programs per se result in a different set of teacher behaviours.

In order to interpret these findings it is necessary to have information on the constraints operating in the system in which the material is being used and their effect on the behaviour of the teacher. That is, it is important to explain why teachers behave in the way they do. Investigation of this may well help to explain the occurrence of certain behaviours in the classroom and be useful to both program developers and teachers. It is to this problem of identifying the teacher's behaviour and why they occur that the present study is addressed.

1.10 The purpose of the Study

The purpose of the present study is to describe the behaviour patterns used by a science teacher in his normal teaching that contribute to the teaching of the nature of science and to develop hypotheses about some of the possible factors affecting those behaviours.

Specifically, the questions to which this study is addressed are:

1. Over a period of time what behaviour patterns does a science teacher use in his normal teaching in different classroom settings that contribute to the teaching of the nature of science?
2. What are some of the variables underlying any observed behaviour patterns within each setting over the period of the study?
3. Which classroom settings does the teacher make the most use of for teaching the nature of science?

1.20 Importance of the Study

It is envisaged that anawers to these questions will be of considerable importance to the teacher, teacher educator and the program developer. It will enable the program developer to be aware of the limitations in teaching the nature of science and incorporate them in new programs. The spelling out of such limitations in new programs will enable the program user to become aware of them

and also sensitize him to analyze his own behaviour in teaching the nature of science. Teachers may recognize how their intents, the particular text material used or the kind of topic can affect the type of behaviour exhibited. It is also hoped that this study will enable teachers to become conscious of their patterns of behaviour including things they do and don't do when teaching the nature of science and the possible reasons contributing to their behaviour. Becoming conscious of present patterns is the first step in rationally modifying that behaviour.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.00 LITERATURE DEFINING NATURE OF SCIENCE FOR THE STUDY

The "Nature of Science" has been defined in the literature in terms of the way the scientist goes about his work (Commission on College Physics, 1972). However, the actual specification of the way the scientist goes about his work may differ according to the view point brought into it - whether it is philosophical or sociological or both. An example of one view point brought into the definition of the way of the scientist, Wish and his associates (1975) in developing their Instrument for Observing Classroom Science Behaviour in the elementary school, described the following behaviours as consistent with teaching and learning the nature of science: Selection of a problem, formulating hypothesis, structuring tests, controlling and manipulating variables, making operational definitions, gathering data, interpreting data and predicting. This view is emphasized by Anderson (1968) who writes that, to teach the nature of science, the student's work should "approximate as much as possible that of the actual investigations of the scientists".

In his view, the scientist in his research investigations spends much time in defining the problems, formulating hypotheses, designing experiments and formulating conclusions and predictions but very little time in the collection of data. He maintained that to teach the nature of science, it is important for the students to be extensively involved in all stages of the process - that is, defining the problem, formulating hypotheses, designing experiment, collecting data and formulating conclusions. Tamir (1976) used similar stages to define the nature of science (inquiry teaching, in his terminology) in the laboratory. Also Lunetta and Tamir (1978) applied similar stages to analyze the content of PSSC and Project Physics laboratory manuals to identify the extent to which they emphasize the processes of science.

So far, the above explanations have viewed the nature of science as a process or method and the teaching of the nature of science as the complete involvement of students in the process.

However, Connelly and his associates (1977) maintain that the nature of scientific inquiry should be viewed in terms of the following:

1. That scientific knowledge is always subject to change and revision - the change occurring whenever the scientific community is persuaded of the value of a proposed revision.

2. That scientific knowledge is always tentative - it is the most adequate account of the world at a particular time.
3. That guiding conceptions of the scientist determine the type of problem selected for investigation and the data he collects.
4. That different guiding conceptions may lead to different legitimate enquiries in the same problem area.

They believe that in teaching the nature of science the above views should be transmitted to the students in some way. These latter statements will be referred to as the "assumptions" of scientific inquiry as oppossed to the "processes" of science. To Connelly and his workers (1977), the guiding conceptions influences the specific stages in the "process" of science such as the choice of the problem, the data collection and even the interpretation of the results. Thus, in contrast to the views of Anderson (1968) and others, the view expressed by Connelly and others is all embracing, recognising both the "process" of science and the "assumptions" of science. This wider view is an attempt at a more pragmatic and realistic view of science.

In this study, teaching the nature of science will be defined in terms of teacher classroom behaviours consistent with the processes and assumptions of science as defined above but specifically as defined by the Classroom Observation Instrument relevant to ESCP (Smith 1969).

That is, in teaching the nature of science, the teacher is expected to extensively engage the students in the processes of science and should convey orally the assumptions of science to the students.

2.10 Studies of Teacher Behaviour Employing Systematic Observation

A wide variety of systematic observational systems have been used to capture the quantitative and qualitative dimensions of teacher-pupil interactions in the classroom in order to obtain an empirical backing for our classroom practices. This attempt started as far back as the work of Horn (1914) on pupil participation, through the work of Anderson (1939) in categorizing the teacher-pupil contacts on a "dominative-integrative" dimension, to the work of Withall (1949) on "learner-centredness", "neutral" and "teacher centredness" and Flander's (1970) concept of "directness" and"indirectness". Since the work of Flanders over 200 observational systems have mushroomed; this includes the early works of Smith and Meux (1962, 1967), Bellack and associates (1966) and many others. The first generation of systematic observational instruments designed to analyze the classroom interactive behaviour of teachers and students were used to describe interaction in all subject areas of the curriculum. For instance, Smith and Meux (1967) used their instrument on strategies of teaching in analyzing the interactive behaviour in Science, Mathematics, History and Social Studies.

Referring to the general nature of the observational systems extent at that time and the fact that they were not designed to capture the specific aspects of science teaching especially laboratory activities, a number of researchers (e.g. Parakh, 1969; Fischler *et al.* 1967-68) developed systems purported to be capable of monitoring science classroom interactions. However, in reviewing these new systems Rosenshine (1970) noted that most of the "science-specific systems" contain very little to distinguish them from the systems developed for use in all subject areas. For example, he noted that the systems developed by Parakh (1969) and Evans and Balzer (1970) contain only one or two items specific to science. However both the science-specific systems and the general systems have been used to investigate science teaching in both the elementary schools and secondary schools.

These studies have always sought to provide a description of science teaching based entirely on the frequency counts of the items included in the instrument or system used for the study. In a study conducted in the science classroom and laboratory, Parakh (1967-1968) recorded that the teacher talks about 75% of the time in the science classroom and about 50% of the time in the laboratory. Snider (1965) using Flanders System of interaction analysis reported similar findings for a sample of 17 physics teachers and on the basis of further

analysis of the kinds of teacher verbal behaviour concluded that much of physics teaching is 'telling'. In a recent study to investigate the use of laboratories in the high school and college levels, Tamir (1977) reported that in all the 31 laboratories observed 11% of the total laboratory time was devoted to 'verification' items while 13% was devoted to 'investigative' items. He noted that out of the 18 teachers involved in the study seven were 'inquiry-oriented', three 'traditional', and the rest equal on both 'inquiry' and 'verification' items.

One point to be made here is that in almost all the studies using systematic observational instruments, no attempt was made to collect data on factors which might have contributed to the sort of behaviour exhibited by the teacher.

A second point is that, only very few studies have been reported on the behaviour pattern of science teachers in different settings or in the same setting over time. In a study to investigate the behaviour pattern of three experienced sophomore biology teachers using Flanders instrument and involving sixteen observations, Urbach (1966) reported that recurring patterns of verbal instructional techniques did exist for each teacher in the classroom. This observation is similar to that of Smith (1969) when he studied the behaviour of three teachers using the ESCP materials for two weeks in different classroom settings which he defined in terms of

the major categories in his instrument - that is, the developing text material, pre-lab, lab and post-lab. He noted that teacher's behaviour within a "classroom setting is relatively consistent in recurring instances of that setting" and that differences occur from one setting to another although he did not provide any data on the daily behaviour pattern of the teachers.

In both studies, the researchers did not attempt to explain why the teachers behaved in the way they did although this would have helped in identifying the constraints in the system. Also in both studies, the teachers' behaviour was not studied on a continuous basis. The teachers selected the times suitable for the observations - a procedure which might lead to the observation of atypical behaviour.

One study which was done over a period of one year to compare the effect of "Indirect/Direct" ratio (I/D) of selected science teachers as measured by Flanders' instrument on students' achievement showed that the higher "I/D" teachers varied in their style of teaching as the year went by (Wolfson, 1973). Apart from the fact that the teachers were observed on only a few occassions during the year, no possible reasons were advanced to explain the "flexibility" in the behaviour of the higher "I/D" teacher.

From these studies, it appears that over a short period definite recurring patterns can be identified while

over a long period of one year some teachers tend to be "flexible" in their behaviour.

However, in all these studies no attempt was made to collect data on factors which might have contributed to the sort of behaviour pattern exhibited by the teacher. Smith (1969) in his study, recommended that the investigation of factors such as teacher's perception of the curricular materials, teacher intent with regard to the individual lessons, students' perceptions of the curricular materials may "pay-off in describing to some extent why teachers and students behave as they do in the classroom". As a beginning, these factors can be studied in our investigation of the behaviour of a science teacher with one class of students on a continuous basis over a period of time. The present study is an initial attempt to describe the behaviour pattern used by a science teacher that contribute to the teaching of the nature of science to one class of students over three weeks and to identify some of the factors which may be contributing to any observed patterns of behaviour.

2.20 Studies on Teachers' Understanding of the Nature of Science

A major objective for many modern school programs has been the students attainment of an understanding of the current conception of the nature of science as expressed by such characteristics as the tentative nature of knowledge and the fact there are different conceptions or methodologies in science (Kimball, 1968; Carey, and Stauss 1968). This implies that the science teacher teaches the nature of science and above all understands the nature of science. However not a single study was identified as investigating the teaching of the nature of science per se although Parakh (1967-68) noted in his study of biology teachers using the BSCS curricular materials that no reference was made by the teachers in his study to the "nature of science" which was one of the items in his instrument. The little research on the nature of science has concentrated on the teacher's understanding of the nature of science and factors believed to contribute to this understanding (Kimball, 1968; Schmidt, 1968; Welch and Pella 1968; Carey and Stauss, 1968, 1970; Billeh and Hasan, 1975). To aid in the measurement of the understanding of the nature of science, a number of test instruments have been developed - the Test for the Understanding of Science (TOUS), the Nature of Science Scale (NOSS), the Nature of Science Test (NOST) and the

Wisconsin Inventory of Science Processes (WISP). The studies by Welch and Pella (1968) and Schmidt (1968) among others indicated that the science teacher's understanding of the nature of science was lower than that of the practicing scientist but higher than that of the students. Schmidt (1968) in his study involving scientists and some science teachers and students indicated further that high ability students scored higher than 50% of the science teachers in his study when TOUS was used as the instrument, thus confirming the already existing notion that some secondary science teachers understanding of science was no better than the students they may be teaching. However, Kimball (1968) noted that a major error in these studies had been the use of a non-representative sample of teachers. The studies by Welch and Pella (1968) and Schmidt (1968) used a cross-section of science teachers which included unqualified science teachers. According to Kimball (1968), "Studies in which the qualifications of the teachers were not controlled are of doubtful value ....." In a subsequent study in which he explored the understanding of the nature of science exhibited by science teachers qualified with a major in science as compared to that of practicing scientists with similar academic backgrounds, he concluded that no differences existed between these groups in their understanding of the nature of science. In the same study, Kimball reported that neither experience of the science teachers nor time of graduation appeared to

have any effect on teachers' concept of the nature of science. Carey and Stauss (1968, 1970) in a number of studies to explore the relationship between experienced science teachers' understanding of science as measured by the WISP instrument and some academic variables (e.g. total university grade point average, total science credits, high school science units, number of years of teaching, physics credits, and total college science hours) noted little relationship between the teachers' understanding of science and the variables used in the study. Similar findings were reported by Lavach (1969) with the TOUS and in a recent study by Billeh and Hasan (1975) using the NOST instrument.

Although, understanding the nature of Science is pre-requisite to teaching it, the results of Kimball's (1968) study shows that qualified experienced science teachers have the same understanding of the nature of science as do practicing scientists. Also, the studies cited indicate that most of the independent variables examined in the studies were found to have no effect on the teachers' understanding of the nature or science.

Even though we can assume from these studies that qualified science teachers understand the nature of science at least as well as practicing scientists, no study was found to have investigated how the teacher's understanding of the nature of science and other factors contribute to the type of behaviour used by the teacher

in his teaching. There is therefore, an urgent need to study the behaviour pattern of the teacher in teaching the nature of science and the factors that contribute to such behaviour. It is to this problem that the present study is addressed.

CHAPTER THREE

DESIGN AND METHODOLOGY

The purpose of this chapter is to provide a detailed description of the project's design and methodology.

3.00 QUESTIONS FOR THE STUDY

The specific questions asked in this study are:

1. Over a period of time what behaviour patterns does a science teacher use in his normal teaching in different classroom settings that contribute to the teaching of the nature of science?
2. What are some of the variables underlying any observed behaviour patterns within each setting over the period of the study?
3. Which classroom settings does the teacher make the most use of for teaching the nature of science?

Apart from factors which emerged from the study, the factors believed to be relevant in providing possible explanations to the teacher's behaviour include

i) Teacher's intent with regard to individual lessons (suggested by Smith (1969))

ii) Teacher's overall intent for the period of the study

iii) Teacher's perception of the students in the class

iv) The topics for the lessons

v) The availability of resources such as text materials and equipment and

vi) Time constraints on the teacher.

3.10 GENERAL DESIGN

The general design for the study can be looked at with the aid of the following illustration:

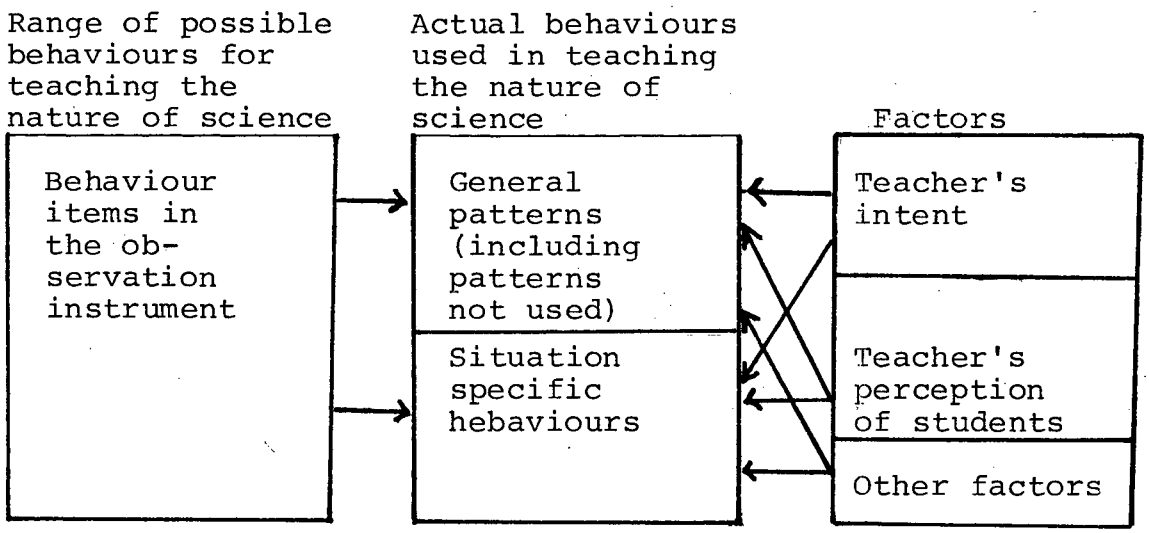

Figure 1

A Representation of the Design for the Study

The range of possible behaviours of the teacher in teaching the nature of science are defined by the items in the observation instrument used for the study. During the study, the teacher's behaviour was observed and coded using the observation instrument. The observed behaviours were examined for general patterns and situation specific patterns and the factors identified in the study were

examined to see the extent to which they provided plausible reasons for the teacher's behaviour.

3.20 METHODOLOGY

In this study, the classroom behaviour of an experienced junior secondary science teacher with one particular class of students was investigated to provide answers to the questions posed in the study. In order to keep track of the teacher's daily behaviour with his class of students the observations were made continuously - that is, each time the teacher came into contact with the students for the purpose of teaching them.

To answer questions one and three - the teacher's behaviour pattern and the setting mostly used in teaching the nature of science - a modification of the Classroom Observation Instrument Relevant to the Earth Science Curriculum Project (Smith, 1969, 1971) was used to code the teacher's behaviour from audio and video tape recordings. The exact procedure followed was as follows: a small, pocket-sized F.M. wireless transmitter (with frequency 33.40Hz) was "worn" by the teacher in the front pocket of his shirt during the lessons to enable both the high and low decibel level of verbal communication between the teacher and the students at individual laboratory benches to be recorded via an F.M. wireless microphone receiver, model ST-3 played into a Califone cassette tape recorder (model 3530) provided with a counter. To record the non-verbal behaviours in the

modified Classroom Observation Instrument Relevant to the Earth Science Curriculum Project (Appendix A) such as "Teacher conducts demonstration relevant to investigation theme", "Students proceed with investigation without direction from the teacher", "Teacher demonstrates use of apparatus or equipment", "Teacher performs part of investigation for student in response to question about procedure", "Teacher grades students on lab procedure as they work", "Teacher moves from station to station", "Student makes own observations", "Students prepare a written report of the details and results of the investigation", "Teacher works mathematical problems for students", "Students graph or otherwise organize data", and "Students compare results with others", a video tape recording was employed in conjunction with the audio tape recording. Also these non-verbal behaviours were noted anytime they occurred. One day of practice was used to establish appropriate sound levels and also to acclimate the students to the presence of the equipment and the investigator before actual recordings were taken.

The recordings obtained for each lesson were played at a later date and coded independently by using the special coding instructions (Appendix B) by the investigator and a graduate student in science education trained in the use of the instrument. The data obtained from the coded sheet were tabulated on a time line in terms of each classroom setting observed and this was used to answer the questions on the behaviour pattern used by

the over time and the classroom setting mostly used in teaching the nature of science.

3.30 FACTORS

Data for the question: "What are some of the variables underlying any observed behaviour patterns within each setting over the period of the study" were obtained by gathering information on pre-specified factors such as the teacher's intent with regard to individual lessons, the teacher's perception of the students in his class as compared to other students at the same grade level, the topics for the lessons, the availability of resources such as text materials and equipment and time constraints on the teacher. At the same time other relevant information was gathered informally through observations and discussions with the teacher.

3.31 The Intent of the Teacher

The intent of the teacher during any particular lesson was defined as the instructional objectives he hoped to attain during that lesson. These instructional objectives can be expressed in terms of behaviours that students are expected to exhibit during the lesson (Klopfer, 1971). Using Klopfer's (1971) scheme of instructional objectives for science teaching as a source, ten statements were constructed. A continuous line with end points labelled 'Strong Emphasis' and 'Low Emphasis' and a box labelled

'not present' are provided in front of each statement (Appendix C). This particular scale was chosen because the main aim was to identify the relative emphasis given to the instructional objectives by the teacher.

This instrument was given to the teacher at the beginning of the study to indicate at the beginning of each lesson which objectives he hoped to achieve in each lesson. The teacher selected the objectives by checking the appropriate point on the scale for each of the ten objective statements. The objectives indicated by the teacher to have high emphasis were taken to be indicative of his intent for the lesson.

The teacher's overall intents for the period of the study were identified by asking him to check the same ten objective statements during the pre-study interview. All the objectives checked by him to be high were taken as the teacher's overall intent.

Informal conversations held with the teacher during his free hours served to clarify some of his intents.

This qualitative information on the teacher's intents both overall and for each lesson were examined for their contribution to the explanation of the teacher's behaviour in each setting.

3.32 Teacher's Perception of his Students

The teacher's general perception of his students was defined in terms of how the teacher characterizes his

students compared to other students at the same grade level. This was identified through the following items in the Interview Schedule (Appendix D) which was administered to the teacher prior to the study. These items are item 4 (In terms of other students in the same grade level you have taught, how would you characterize the students in this class?), item 6 (How would you characterize the students in terms of participation in class, asking questions, contributing unsolicited ideas, responding to teacher's questions, etc?), item 7 (Would you say the students enjoy doing science?) and item 8 (Would you say they enjoy carrying out activities such as experiments in class?).

Apart from the initial interview, the teacher was interviewed after each lesson either immediately or during the lunch break to indicate how he perceived the just-ended lesson. Initially only variations of a single question such as "What stands out for you about the lesson you've just taught?" was asked. Since the teacher had a busy schedule this was done in order not to waste his time in responding to too many questions. Also it was hoped that the question would reveal among other things, the teacher's perception of the students during the lesson. Apart from this major question, other questions believed by the investigator during each lesson to have a bearing on any observed behaviour were asked. For example, in the first lesson where the students were observed to only respond to

the teacher's questions and not ask questions themselves, the investigator asked the question, "Why did the students not ask questions during the lesson".

The various sources of the information on the teacher's perception of the students were examined to see how they contributed to the teacher's behaviour in each setting.

3.33 Topics Chosen for the Lessons

It was thought that the particular topics chosen for the lessons and their substantive content might contribute to the teacher's behaviour in teaching the nature of science and also in determining to some extent the classroom settings used for teaching the nature of science. Data on this was obtained by identifying the specific topics for each lesson. For instance, a topic on the historical development of the microscope involved teaching the nature of science in the "developing text material" setting. Also a topic on the observation of a student's own blood caused the teacher to outline certain safety precautions to be taken compared to that of observing already prepared blood slides.

3.34 Availability of Materials

The materials included both textual materials and equipment. The investigator believed that where materials were not available for, say student experimentation, the type of behaviour exhibited by the teacher might be different

from a situation where materials were available. Data on this factor were obtained during each lesson; depending on the lesson, the investigator recorded in the field notes whether there were sufficient materials for the kinds of activities in the classroom.

3.35 Time Constraints on the Teacher

This involved determining how the teacher felt about the amount of time he had to cover the materials in the course and the adequacy of assistance from lab technicians. Data on this were obtained from item 9 and 10 of the Interview Schedule (Appendix D) concerning the amount of lab assistance from the lab technician and the pressure to complete the topics in the course respectively. At the same time, the investigator noted how much assistance the technician rendered during each lesson.

3.40 THE PRE-STUDY INTERVIEW

Three days prior to the three-week observation period, the teacher was interviewed with the aid of an Interview Schedule (Appendix D) which he responded to by writing down his responses. This was intended to provide certain information about the teacher and the students including the teacher's perception of the students, his overall intent, the time constraints on the teacher and the adequacy of assistance from the lab technician.

3.41 Daily Schedule

Prior to the daily observations, the teacher was given sufficient copies of the Objectives for Science Teaching forms (Appendix C) to indicate his intents for each lesson by checking each of the ten statements. These were completed and collected at the beginning of each lesson. The rationale behind allowing the teacher to keep the blank forms until the beginning of each lesson was to give him ample time to reflect on his intents for the lessons.

During each lesson, the total behaviour of the teacher was recorded on an audiotape and a videotape. At the same time the non-verbal behaviours were recorded in the field notes anytime they occurred with the number on the numerical counter of the tape indicating where such behaviour occurred. Other information collected informally during the study was done through the use of the Guiding Form (Appendix E).

3.42 Post Lesson Interview

The teacher was interviewed informally immediately after each lesson or, where this was not possible, during the free hours of the teacher. Initially, variants of the question: "What stands out for you about the lesson you've just taught?" were asked in order to unpack the teacher's innate feelings about the lesson, especially his perception of the students and intents for the instruction. Other questions used to follow up the initial question

depended on the observers identification of any "interesting" phenomenon during the lessons and the amount of time the teacher had to spare.

3.50 THE OBSERVATION INSTRUMENT

3.51 Description of Smith's Instrument

From the definition of the teaching of the nature of science used in this study, a search was made through the literature to identify any systematic observation instrument having items consistent with this definition. From the available instruments including those in the anthology, Mirrors of Behaviour (Simon and Boyer, 1967, 1970a, 1970b, 1974), the Classroom Observation Instrument Relevant to ESCP (Smith, 1969, 1971) was found to contain items of interest for the present study. In this study it will be referred to as Smith's Instrument.

The instrument groups teacher and student behaviours into four major categories consistent with classroom settings expected to occur in ESCP classes. These settings were: Developing text material, Pre-lab, Laboratory and Post-lab discussion.

Developing text material: This is defined as the written, graphical descriptions, definitions, explanations, and questions (exclusive of laboratory exercises) representing the content of a chapter. The text material may be developed through informal lecture, discussion, demonstration, audio-visual presentation, or a combination

of the above approaches.

Pre-Laboratory: This is defined as the brief interval prior to the lab activity in which the problems to be investigated are introduced by the teacher or the students. The introduction to a laboratory investigation may be done in several ways, e.g. demonstration, discussion or assignment review.

Laboratory: This is the interval when students are actively engaged in collecting data related to the investigation or analyzing data provided in the ESCP text.

Post-Laboratory Discussion: This is the period during which laboratory results are analyzed. This discussion is characterized by reporting of results and references to laboratory data to support interpretations.

These broad categories are further divided into subcategories each of which includes several behavioral items. The subcategories are labelled alphabetically from A to O and the specific behaviour items under the subcategories are labelled as follows: A1, A2, ... An; B1, B2,.... Bn; etc. The major behaviour items included in the instrument according to the broad categories are:

Developing text material setting

1. Demonstrating behaviours relative to the nature of Science.
2. Discussion about the process of Science.

Pre-Lab

1. Identifying the problem to be investigated.
2. Instructions on conduct of investigation.

Laboratory

1. Identifying the major components of the investigation.
2. Response to student's questions.
3. Evaluation of students' performance.

Post-Lab

1. Analyzing the data.
2. Interpreting the results.

The instrument was developed from the observation of an ESCP class and the objectives and philosophy of the Earth Science Curriculum Project which, like most recent curricular materials, emphasizes the teaching of the nature of science. The list of behaviour items identified from these sources were sent to judges consisting of ESCP writers and trial teachers who rated each of the items as (a) consistent with the nature of ESCP, (b) inconsistent with the nature of ESCP or (c) neutral. From the judges' ratings, items whose median were from 1.00 - 1.49 were considered consistent with the ESCP philosophy and objectives; those with median from 1.50 - 2.49 were considered neutral while those with values of 2.50 - 3.00 were considered inconsistent with ESCP.

The reliability of measures from the instrument was established through the determination of inter-observer agreement (P) for which a value of 74% was obtained.

The instrument conforms to a sign system as described by Mitzel and Medley (1963). This is because the items do not exhaust all possible teacher and student behaviour in

the classroom but rather represent items related to the ESCP inquiry approach that were of interest to Smith. In using the instrument therefore, each behaviour item is recorded whenever that particular behaviour occurs. Specially formulated ground rules (Appendix B) for helping the observer to code the items in the instrument are available for users of the instrument.

Apart from Smith (1969), Tamir (1977) used the instrument to investigate how laboratories are used in Israel at the high school and undergraduate college levels. In selecting the instrument for this purpose, Tamir described it as "the most suitable of available instruments for observing laboratory work". Since he was more interested in the "processes" of science he did not use the "Developing text material" category.

3.52 Modification of Smith's Instrument for the Study

From the definition of the teaching of the nature of science used in this study - that is, the teacher's classroom behaviour should be consistent with promoting the processes of science as well as conveying the historical and philosophical assumptions of science such as viewing scientific knowledge as only tentative, that there are many conceptions or methods through which knowledge can be obtained - the philosophy of the ESCP curriculum was examined to see how similar it was to the view used in the study. Also the specific items in the

instrument were examined to see how they derive from the view of the nature of science in this study.

In reviewing the ESCP material, Investigating the Earth (ESCP, 1965), the following statements were found to be pertinent to the study:

> ESCP is intended to give the student an understanding.....of the methods of science.... In the laboratory....the student makes observations and measurements, and he interpretes data....
> The body of scientific knowledge at any given moment represents only one stage in man's effort to understand and explain the universe....
> Today's useful theories may be the half-truths of tomorrow...., demonstrate how scientists work and exmphasize the.... knowledge that come from investigation and discovery (ESCP, 1965).

The view of the nature of science underlying these statements is that science consists of processes which students should be involved in, that scientific knowledge is tentative and keeps changing and that there is not just one method or theory (conception) of science but that there are several theories and methods. This view of the nature of science is consistent with the view used in this study.

From this view of the nature of science, statements such as the following could be derived:

1. Teacher talks about the tentative nature of knowledge in science.
2. Teacher talks about the development of knowledge in science.
3. Teacher talks about the place of theory in science.

4. Students identify relevant problems for investigation.

5. Students state hypothesis about the relationship between variables.

6. Students devise procedures for investigation.

7. Students perform investigation.

8. Students interpret data and results.

9. Students make predictions from results or conclusions.

Most of these statements and others which can be deduced from the above view were found to be present in Smith's Instrument. Thus, the instrument is consistent with the view of the nature of science used in this study and therefore appropriate for the description of a teacher teaching the nature of science.

However, as indicated by Smith (1969) some of the items rated by the judges to be inconsistent with ESCP philosophy were still included in order to identify "behaviours antithetical in principle to the ESCP approach".

In adopting the instrument for this study, all the items with median values of 2.50 and above were regarded as being highly inconsistent with the teaching of the nature of science and were therefore removed from the instrument thus leaving only neutral and consistent items. The following is a list by major categories of items dropped and their mean values: Developing text material:

1. Teacher asks students to memorize names of objects. 2.75.

2. Teacher asks students to memorize classes of objects or Geologic structures. 2.75.

3. Teacher asks students a question requiring only a "yes" or "no" response. 2.50

4. Students respond to teacher questions with a "yes" or "no" answer. 2.75.

Pre-lab:

1. Teacher gives step-by-step directions for performing investigation. 2.75

Laboratory:

1. Teacher describes observation students should make. 2.50.

2. Teacher tells student his procedure is wrong. 2.75.

3. Teacher sits at desk or leaves room. 2.75.

4. Teacher says or does nothing in response to student question about investigation procedure. 2.90.

Post Lab:

1. Teacher tells student his results are incorrect. 2.50.

2. Teacher describes conclusions students should deduce from results. 2.50.

3. Teacher suggests that all students should arrive at the same conclusions. 2.90.

In addition, words or phrases like "Earth Science" and "Geologic Structures" were either entirely removed or replaced by the word "Science".

Other possible items derived from the view of the nature of science used in the study were added to the instrument. The items added are given in the list below for the major settings.

Developing Text Material:

1. Teacher asks student to find out the answer.

Pre-lab:

1. Teacher asks students to formulate hypothesis for the experiment.

2. Teacher asks student to operationalize the variables in the experiment.

3. Teacher demonstrates use of apparatus or equipment.

4. Student states hypothesis for the investigation.

5. Student provides operational definitions for the variables in the study.

6. Teacher states hypothesis for investigation.

Laboratory:

1. Student asks teacher for help with investigation procedure.

Because the classroom behaviour was recorded on video and audio tapes, the ground rules for recording the behaviour (Appendix B) were modified slightly to take this and other things like teacher demonstrations during laboratory settings into account. The modified instrument and the ground rules appear in Appendix A and B.

Using Smith's classification, the items in the modified form were identified to be neutral (N) or consistent (C) with the teaching of the nature of Science (as in Appendix A). Thus all the behaviour items with rating values of 1.00-1.50 were regarded as consistent with teaching the nature of Science. In the study by Smith (1969) these were considered to be consistent with the philosophy and objectives of the ESCP curriculum. In addition, certain items, A3 (teacher emphasizes historical development of knowledge in Science) and A4 (Teacher

explains how information is obtained in Science and almost all the new items introduced into the original instrument were considered to be consistent with teaching the nature of Science. In Appendix A, the items are identified as (C) or (N) denoting whether they are consistent or neutral with respect to teaching the nature of Science respectively.

3.53 Observer Training Program

Systematic observation of the classroom settings with the aid of the video and audio tapes were carried out by the investigator throughout the study. Initial training in the use of Smith's Instrument involved following part of the training program recommended by Smith (1969). This involved the following steps:

1. Familiarization with the major categories and the location of student's and teacher's behaviour items.
2. Familiarity with the abbreviated form of the items (Appendix F) and the meanings of the items.
3. Knowledge of the ground rules for coding behaviours on the instrument (Appendix B).
4. Coding of three tape recorded science lessons on three separate occassions.

Steps one through three took approximately two weeks to master. The recording of the lessons was done on different occassions in a Junior High School classroom

by the investigator with the aid of an audio tape and an F.M. wireless microphone and receiver in a period of two weeks.

During the recording sessions, the investigator took notes using questions similar to the one used in the actual study (Appendix E). The list of objectives was also tried on two of the three teachers involved in the "pre-study exercise". Because of the commitments of the teachers only one teacher was interviewed after the lesson and his comments noted.

It is interesting to note however that the guiding questions provided much needed focus because in an earlier observation involving two student teachers, (and where guiding questions were not used) the investigator recorded every little thing that happened in the class even though most of them were found after discussion with my advisor, to be unrelated to the questions of the study and therefore irrelevant.

The tape recorded lessons were coded and kept till a later date when it was used in the training of a second coder, a graduate student in Science Education. The training of the second coder was similar to that of the investigator. It involved one week of familiarization with the items in the instrument, and one week of coding five tapes each including more than one setting. Definitions of some of the items were clarified during this

period and inter-rater agreement was determined for each setting.

3.54 Observation Technique

A cassette tape recorder, radio transmitter and radio receiver were used as already described to record the verbal communication between the teacher and the students. Memorex C-120 cassette tapes were used to make the recordings. The F.M. wireless microphone receiver and the cassette tape recorder were placed on the observer's table at the back of the room. The non-verbal aspects of the behaviour in the classroom were recorded on a portable video recorder situated near the investigator's table and focussed mainly on the positions of the teacher. It's microphone was suspended from the ceiling in the middle of the room. Concurrently, the non-verbal behaviour relevant to the instrument were recorded in the field notes anytime they occurred with the aid of the recording form (Appendix F). The Guiding Form was used to gather further information.

At the end of each lesson both the video and audio recordings were synchronised and played to identify any inaudible verbal behaviour of the students. Any inaudible verbal behaviour was noted and clarification sought with the teacher where possible. On reaching home, the audio-tapes were replayed to identify and note down any questions which might crop up. During the two hours bus

ride to the school each day, the investigator used the time to refresh his memory on the items in the various settings, replan the guiding questions by adding any new questions materializing from the previous lesson, read through the relevant sections in the recommended lab text including the activities for the day and the post lab questions on the previous day's lesson. Reflection on the previous lessons also enabled the investigator to replan the questions to be included in the post lesson informal interview with the teacher.

3.60 THE SCHOOL SETTING

The teacher participating in this exploratory study was selected by a committee of two faculty members in the Department of Science Education who were conversant with the teacher's work. The most important factors considered in selecting the teacher for the study were (1) that he taught junior secondary science (2) that he had at least 5 years of science teaching experience (3) that he was willing to have an observer in his class (4) that he was likely to include teaching the nature of science in his daily teaching.

The teacher selected for the study had a master's degree in Science Education and 14 years of science teaching experience - 7 years in an elementary school where the ESS Curriculum was used, 2 years in a university and 5 years in the Junior Secondary School where this study was conducted.

The school itself was situated in a residential area of a suburb of a large metropolitan area and was a mixed day school in terms of the sex, ethnic and socio-economic background of the students. The last factor probably stemmed from the fact that the main occupation of people in this suburb was trading (only a small number were professionals) with an average income of approximately ten to eighteen thousand dollars. Thus most of the students come from the middle and lower middle income groups.

The classes in the school were not streamed in any way - the students selected or "sign up" for the teachers they liked to work with. Normally, the school operated on a five period day but during "sign up" days when students in grades eight and nine selected their teachers, the duration of the periods were shortened from 60 minutes to 50 minutes to allow for a sixth period. The teacher taught a grade eight class, two grade ten classes and a grade 9 class in that order each day. The class observed in this study was a grade ten class of students of average to above average ability.

Apart from his primary duties, the teacher was also actively involved in a number of teacher association and community activities.

From the initial interview with the teacher prior to the study, the teacher's overall intents for the course during the period of the study and his perception

of the students in the class chosen for the study compared to other students at the same level were identified through his response to the Interview Schedule (Appendix D). The teacher's overall intents were identified to be:

1. Students should acquire specific science-related manual skills - skills in microscopy.
2. Students should become aware of the technological applications of science.
3. Students should develop their interests and attitudes towards science, e.g. acceptance of scientific inquiry as a way of thought.
4. Students should apply scientific knowledge and methods to other problem areas.
5. Students should learn specific course content.
6. Students should observe and measure some phenomenon.

On his perception of his students, the teacher was found to perceive his students as exhibiting the following attributes in his class:

1. Show above average participation in class.
2. Ask a lot of questions in class.
3. Contribute unsolicited ideas in class.
4. Respond always to teacher's questions.
5. Always do assignments given to them.
6. Are average to above average in academic standing and hardworking.
7. Enjoy doing science and carrying out experiments in science.

In terms of time constraints, the teacher indicated that the semester system did not allow enough time for

covering topics in the course.

The topics dealt with by the teacher during the period of the study were taken from Unit one - Cells, Reproduction and Heredity - of the prescribed lab text, Extending Science Concepts in the Laboratory (Schmidt, 1970). From statements in the Curriculum Guide (Province of British Columbia, 1970) science was conceived as an inquiry process involving observations, organization of data and explanations which may take the form of model building, induction, deduction and speculations, and that all the different scientific methods involve observations and explanations. Thus science is viewed as a process; the philosophical and historical aspects of science were not considered essential in this laboratory text.

The lab text itself consisted of a series of experiments designed to convey certain concepts to the students. It is recommended in the text that whenever possible, these investigations should be performed by the students. Each investigation in the lab text is preceded by a short introduction on the nature of the investigation and sometimes background information. This is followed by a list of apparatus and materials needed for each experiment. The directions for conducting the experiments are interspersed with "procedure" questions that focus the students attention on the observations and conclusions to be made from the activities. Each experiment is followed by a series of graded (post investigation) questions aimed

at consolidating the student's observations and conclusions. According to the Curriculum Guide, concepts emerging from the experiments should be related to a "meaningful body of scientific knowledge which the students understand and can use to solve problems" (Province of British Columbia, 1970).

However, the emphasis on the student's acquisition of certain skills and techniques in contrast to subject matter content leaves a serious gap in the student's knowledge. The teacher, therefore has to identify these gaps and bridge them by introducing relevant substantive structure whenever this is needed for a complete understanding of a phenomenon.

Finally, the text recommends that a teacher following the course should move from station to station during lab periods to give specific directions and attention to students requiring them.

3.70 INTEROBSERVER AGREEMENT

In the original study in which Smith's Instrument was developed, the reliability of the instrument was estimated by obtaining measures of interobserver agreement between two outside observers (Smith, 1969). The percent of interobserver agreement was calculated by the formula:

$$P = \frac{\text{number of agreements}}{\text{number of agreements + number of disagreements}} \times 100$$

.....(1)

where P = the percentage of agreement;
number of agreements = the frequency with which the observers agreed an item occurred plus the number of items observers agreed did not occur (each of these latter agreements were recorded as having a frequency of one for each classroom setting observed);
number of disagreements = number of times observers disagreed on the frequency with which an item occurred.

This formula was also used by Tamir (1977) to estimate the reliability of a study he conducted using Smith's Instrument. However, it appears that the inclusion of items which were not observed to occur in the determination of the reliability greatly inflates the value for the percentage agreement. For the training period in this study, interobserver agreement was calculated first by using the entire procedure followed by Smith, that is, by using the above formula and secondly by using the same formula but eliminating the number of items coders agreed did not occur from the "number of agreements". Also because of the nature of the questions asked in the study, the percentage agreement was determined for each of the four settings. This is in agreement with the observation made by Frick and Semmel (1978) that observer agreement should be determined "on the same unit(s) of behaviour that will be used in data analysis", that is, if comparisons are to

be made of groups of categories as is planned for this study, interobserver agreement measures should be based on total frequencies for the groups of categories.

On the above basis, the following percentages of agreement were obtained using the two procedures for each of the major categories.

Developing text material	Procedure 1	Procedure 2
Prelab	95.8	83.3
Laboratory	96.4	88.9
Post laboratory	91.5	82.1

This portrays the inflation accompanying the use of the first procedure. The mean percentage agreement from the second procedure was 81.7%. In using the instrument Smith obtained percentage agreement of 74% while Tamir obtained an agreement of 82%. Thus, the value obtained for this study, 81.7% can be considered to be good when compared to those obtained in the above studies.

CHAPTER FOUR

DATA, RESULTS AND ANALYSES

4.00 GENERAL INTRODUCTION

The previous chapter surveyed the methodology for answering the three questions in the study, namely:

1. *Over a period of time, what behaviour patterns does a science teacher use in his normal teaching (in different classroom settings) that contribute to the teaching of the nature of science?*

2. *What are some of the variables underlying any observed behaviour patterns within each setting over the period of the study?*

3. *What classroom settings does the teacher make the most use of for teaching the nature of science during his normal teaching?*

In the present chapter, the findings of the study are presented and discussed in relation to the three questions. Questions one and two are discussed together for each of the four settings - the developing text material, prelab, lab and postlab settings, while question three is discussed separately.

4.10 QUESTIONS ONE AND TWO - BEHAVIOUR PATTERNS

The first question:

"Over a period of time, what behaviour patterns does a

science teacher use in his normal teaching (in different classroom settings) that contribute to the teaching of the nature of science" was answered by examining the single occurrences of each setting and the summary of the frequencies of the items in each setting together with the participant observation data collected during the study. These data were examined for each of the settings over the three-week observation period to identify the following behaviour patterns of the teacher.

I. The General Behaviour Patterns of the Teacher.
This class of behaviours was arrived at by examining the above sources to identify the following behaviours:

i) Consistently used General Behaviours.
This group of general behaviour included any behaviour item identified to be used in all the lessons in a particular setting

ii) Unused General Behaviours.
These are general behaviours identified by behaviour items which were not used in any of the lessons in a particular setting.

iii) Inconsistently Used General Behaviours.
This groups all those general behaviours identified by behaviour items which were used in some but not all lessons but which were judged from the informal data collected during the study to be a general pattern of

the teacher.

II. Situation Specific Behaviours of the Teacher. The identification of this class of behaviour involved examining the data sources to identify the remaining behaviour items which were used in some but not all lessons but which were considered to be situation specific due to the prevailing conditions as will be explained later on.

The second question in the study - "What are some of the factors underlying any observed differences in patterns within each setting over the period of the study"? - was answered by qualitative analyses of the factors used in the study (i.e. those chosen a priori) and those which emerged from the study (i.e. from the informal data collected during the study) to identify which ones and to what extent they offer plausible explanations to the observed behaviours.

4.20 DEVELOPING TEXT MATERIAL SETTING

4.21 Introduction (from informal data)

This classroom setting occurred on six different occassions out of the total of ten class periods observed and for the first class period it was the only instructional setting observed. During this setting, the teacher talked most of the time (this was explained by the teacher to be his general style of introducing new topics by giving a "lecture"), infrequently asked questions and never encouraged students to ask questions. Students were never observed to

contribute unsolicited responses (although the teacher indicated in the initial interview that his students generally demonstrated this behaviour in his classes) and responded only when the teacher asked questions.

In the first lesson in this setting, the teacher dealt with the "historical development and use of the microscope" in biological work. He did this by using historical vignettes to demonstrate how the microscope has increased our knowledge of the microscopic world of plants.

Lesson 2 was mainly a recap of lesson 1 but the teacher used the latter part of the time to demonstrate the parts of the microscope using an actual compound microscope and a drawing of a compound microscope in the lab text.

Lesson 3 dealt with questions on the parts of the microscope in the lab text. However, all the questions were not answered during the lesson because some of them required the use of reference sources to provide satisfactory answers.

Lesson 7 dealt with a generalized plant cell but the teacher used the first part of the lesson to review lesson 1.

In lesson 9 the teacher talked about the structure of the human blood from handouts given to the students.

In lesson 10 which dealt with the internal structure of the leaf, the teacher referred students to the drawing of a transverse section of a leaf in the lab text and discussed the different layers (palisade layer, spongy

mesophyll, epidermis, etc.) and their functions.

4.22 General Behaviour Pattern of the Teacher in this Setting.

The general behaviour patterns of the teacher were identified by examination of the data in Tables I and II and Fig. 2, together with information collected informally. Table I presents the different behaviour items used in each of the six lessons in this setting together with their frequencies and the duration of each lesson in the setting. Table II on the other hand summarizes the frequencies of all the items in the modified Smith instrument over the six lessons observed in the setting. It includes those behaviours which were not used by the teacher in any of the lessons. Figure 2, is a graph of the summary data in Table II. It shows how the total frequency of the individual items relate to the number of different lessons (settings) in which the individual behaviour items are used.

i) Consistently used General Behaviours.

From examining Tables I and II and Fig. 2, the general behaviour pattern of the teacher as identified by behaviour items used consistently in all the six developing text material lessons was as follows:

1. The teacher encourages students to "observe" and "name" objects and structures (D3* and D5).

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* The letters and numbers in the parenthesis after each behaviour represent the identification symbol of the behaviour item in the modified Smith instrument.

TABLE 1

Behaviour Items Observed per Single Occurrences
Of The Developing Text Material Setting on a Time Line

Lesson No.	Duration (minutes)	Behaviour Items Observed	Frequency of Items
1	48	A3 T emp hist dev of knldge in S	14
		A4 T exp hw info is obt in S	5
		B1 T aks S to exp why sm phen occd	8
		B2 T aks S to spec abt fut or pst phen	2
		B3 T aks S to def nw wds in text	5
		C4 T gvs dir ans to S ques	1
		D1 S exp why sm phen occd	5
		D2 S def nw wds used in text	5
		D3 S nam obj or str	2
		D5 S obs obj or str	5
		D8 S rel nw info to tpc of disc	1
2	21	A3 T emp hist dev of knldge in S	1
		A4 T exp hw info is obt in S	2
		B1 T aks S to exp why sm phen occd	2
		B2 T aks S to spec abt fut or pst phen	1
		D1 S exp why som phen occd	2
		D3 S nam obj or str	7
		D5 S obs obj or str	23
3	12	B1 T aks S to exp why sm phen occd	5
		B2 T aks S to spec abt fut or pst phen	4
		B3 T aks S to def nw wds in txt	2
		D1 S exp why sm phen occd	5
		D2 S def nw wds usd in txt	2
		D3 S nam obj or str	12
		D5 S obs obj or str	6
7	6	A3 T emp hist dev of knldge m S	2
		B1 T aks S to exp why sm phen occd	1
		D1 S exp why sm phen occd	1
		D3 S nam obj or str	2
		D5 S obs obj or str	1

continued...

TABLE 1 - (continued)

Lesson No	Duration (minutes)	Behaviour Items Observed	Frequency of Items
9	9	B3 T aks S to def nw wds in txt	1
		D2 S def nw wds in txt	1
		D3 S nam obj or str	4
		D5 S obs obj or str	3
10	15	B2 T aks spec abt fut or pst phen	8
		B3 T aks S to def nw wds in txt	1
		D2 S def nw wds usd in txt	1
		D3 S nam obj or str	6
		D5 S obs obj or str	1

TABLE 1 - (concluded)

TABLE II

Summary of Observations For The Developing Text Material Setting as Recorded on the Modified Instrument

Number of Times Setting Was Observed: 6		
Behaviour Items	No. of Settings (lessons) in which Behaviour Occurs	Frequency of Behaviour
A0 NATURE OF SCIENCE		
A1 Teacher distinguishes between fact and theory	-	-
A2 Teacher stresses the tentative nature of knowledge in science	-	-
A3 Teacher emphasizes historical development of knowledge in science	3	17
A4 Teacher explains how information is obtained in science	2	7
A5 Teacher identified unsolved problems in science	-	-
B0 TEACHER QUESTIONS RELATIVE TO STUDENT PROCESSES		
B1 Teacher asks students to explain why some phenomenon occurred	4	16
B2 Teacher asks students to speculate about the occurrence of future or past phenomena	4	15
B3 Teacher asks students to define new words used in text	4	9
C0 TEACHER RESPONSE TO STUDENT QUESTIONS		
C1 Teacher refers student question back to student	-	-
C2 Teacher answers student question with an analogy	-	-

continued...

TABLE II - (continued)

Behaviour Items	No.of Settings (lessons) in which Behaviour Occurs	Frequency of Behaviour
C3 Teacher responds to student question with, "I don't know but will find the answer for you"	-	-
C4 Teacher gives direct answer to student question	1	1
C5 Teacher asks students to find out answer	-	-
DO STUDENT PROCESS STATEMENTS		
D1 Student explains why (causality) some phenomenon has occurred	4	13
D2 Student defines new words used in text	4	9
D3 Student names objects or structures	6	33
D4 Student classifies objects or structures	-	-
D5 Students observes objects or structures	6	39
D6 Students states hypothesis	-	-
D7 Student uses space/time relationships in explanation or description	-	-
D8 Student relates newly introduced information to topic of discussion	1	1
D9 Student identified problems for possible investigation	-	-

TABLE II - (concluded)

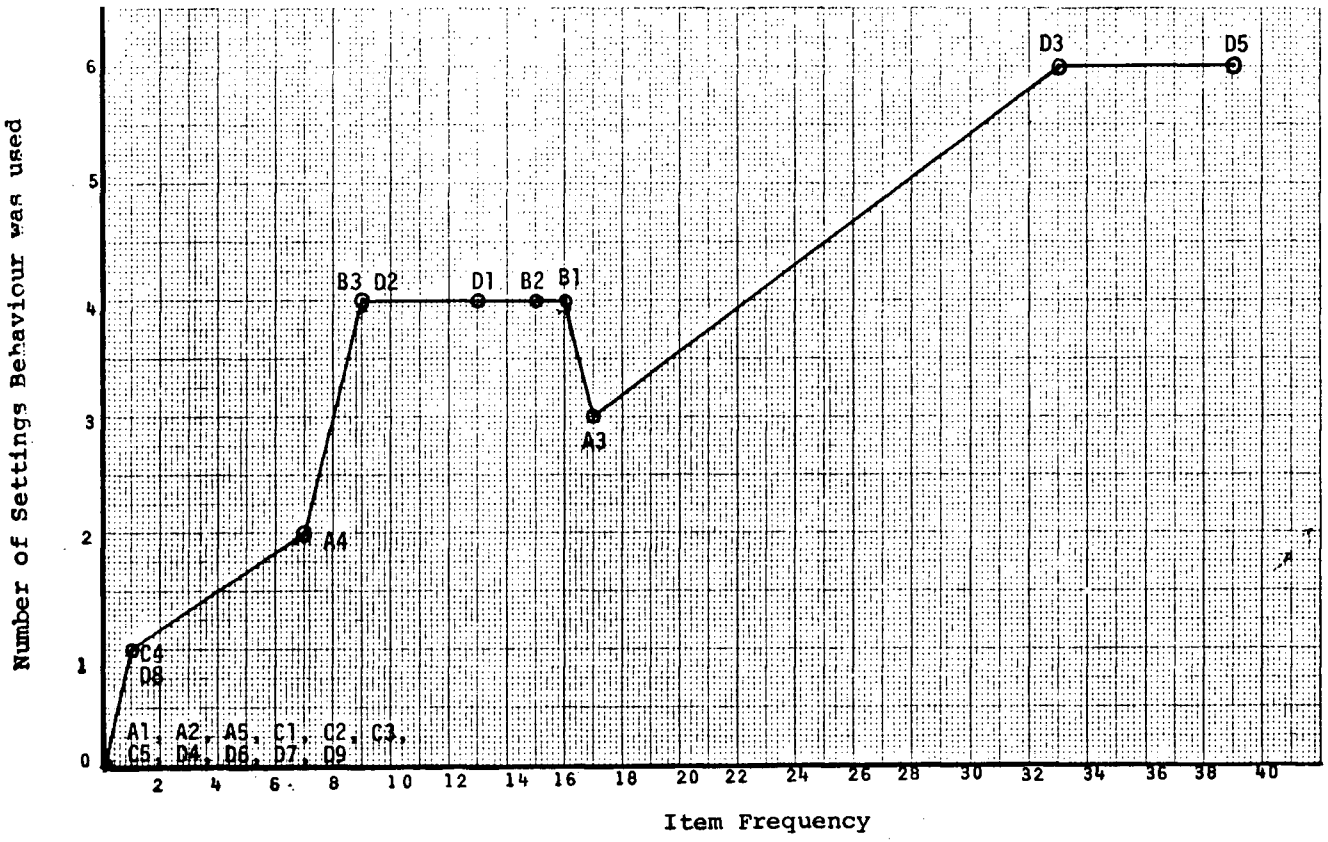

Figure 2. Plot of Item Frequency Against the Number of Settings Behaviour was used in the Developing Text Material Setting

This behaviour was observed frequently throughout this setting and also in the laboratory setting. The high frequency of this behaviour compared to the other possible behaviours points to a specific focus for many of the questions asked by the teacher in this setting. That is most of the questions asked by the teacher required the students to "name" or "observe" an object or structure or a phenomenon. The "naming" of an object or structure is however considered to be neutral with respect to teaching the nature of science.

The use of this behaviour - encouraging students to "name" and "observe" objects and structures - seems to be partially related to the nature of the topics dealt with in this setting (Table III) and the approach used. In lesson 1 which dealt with the "historical development and use of the microscope", the teacher performed a demonstration on Brownian motion using an overhead projector, asked students to observe photographs of Robert Hooke's microscope and the drawing of a feather and cork cells by Robert Hooke in the reference book . Thus the students had much opportunity to "observe" objects, structures and phenomenon. The only opportunity for naming an object was when the teacher asked the students to identify a model of the DNA molecule displayed on a shelf during the lesson. This probably explains the low frequency nature of this behaviour item in this lesson. In lessons 2 and 3, students were asked to "observe" and "name" the different parts of the microscope. In lesson 3 which was an extension of lesson 2

TABLE III

Lesson Topics For Each Setting According To Order of Occurrence

Lesson No.	Setting	Topic
1	Developing text material	Historical development and use of the microscope in biology
2	Developing text material Pre-lab Laboratory	Parts of the microscope Operation and care of the microscope Operation and care of the microscope
3	Developing text material Post-lab Pre-lab Laboratory	Parts of the microscope Operation and care of the microscope Characteristics of the image and depth of field Characteristics of the image
4	Post-lab Pre-lab Laboratory	Characteristics of the image Depth of field Depth of field
5	Post-lab Pre-lab Laboratory	Depth of field Magnification with the microscope Magnification with the microscope
6	Post-lab	Magnification with the microscope
7	Developing text material Pre-lab Laboratory	A generalized cell Observation of living and non-living plant cells Observation of living and non-living plant cells
8	Pre-lab Laboratory	Observation of living and non-living plant cells Observation of living and non-living plant cells
9	Post-lab Developing text material Pre-lab Laboratory	Human skin cells Structure of human blood Observation of human blood cells Observation of human blood cells

continued....

TABLE III - (continued)

Lesson No.	Setting	Topic
10	Post-lab	Observation of human blood cells
	Developing text material	Internal structure of a leaf
	Pre-lab	Observing the various kinds of cells in a leaf
	Laboratory	Observing the various kinds of cells in a leaf.

TABLE III (concluded)

students answered text questions related to the parts of the microscope. In lessons 7, 9 and 10 students observed and named the parts of a generalized cell, the components of blood and inner structure of a leaf respectively. The low frequency nature of the behaviour item - "students observe objects or structures" - in lesson 10 is explained by the fact that students observed only one object - a cross-section of the leaf, in their lab text. Thus, the nature of the six topics dealt with and the approach used in this setting lend themselves to allowing students to "observe" and "name" objects, structures and phenomena.

Also, the teacher's intents for each lesson (Table IV) seem to suggest a possible explanation for the consistent use of this behaviour in all the lessons in this setting. In all the lessons with the exception of lessons 2 and 3, the teacher had as one of his intents that "students should observe and measure some phenomenon" (this also happens to be one of the teacher's overall intents). This objective or intent of the teacher will require asking the students to observe a number of objects, structures and/or phenomena in order to achieve it. It can therefore be regarded as contributing to the use of this behaviour in lessons 2 and 3.

ii) Unused General Behaviours.

The general behaviour pattern identified from behaviour items not used in any of the lessons in Table II and Fig 2 were:

1. Teacher refers students questions back to

TABLE IV

Teacher's Intents For Each Lesson

Lesson No.	Objectives
1	a) Student should observe and measure some phenomenon b) Students should become aware of the technological applications of science c) Students should recognize the philosophical limitations and historical background of science
2	a) Students should become aware of the technological applications of science b) Students should acquire specific science-related manual skills c) Students should interpret data and/or formulate hypotheses
3	a) Students should acquire specific science-related manual skills b) Students should develop their interests and attitudes towards science c) Students should become aware of the technological applications of science
4	a) Students should observe and measure some phenomenon b) Students should identify a problem and/or seek a solution c) Students should acquire specific science-related manual skills
5	a) Students should learn specific course content b) Students should observe and measure some phenomenon c) Students should acquire specific science-related manual skills
6	a) Students should learn specific course content b) Students should observe and measure some phenomenon c) Students should identify a problem and/or seek a solution

continued...

TABLE IV - (continued)

Lesson No.	Objectives
7	a) Students should observe and measure some phenomenon b) Students should acquire specific science-related manual skills c) Students should develop their interests and attitudes towards science
8	a) Students should observe and measure some phenomenon b) Students should acquire specific science-related manual skills c) Students should develop their interests and attitudes towards science
9	a) Students should observe and measure some phenomenon b) Students should apply scientific knowledge and methods to other problem areas c) Students should acquire specific science-related manual skills
10	a) Students should learn specific course content b) Students should observe and measure some phenomenon c) Students should acquire specific science-related manual skills.

TABLE IV - (concluded)

students (C1)

2. Teacher answers student questions with an analogy (C2)
3. Teacher responds to student questions with "I don't know but will find out the answer for you" (C3).
4. Teacher asks students to find out the answer themselves (C5).

The non-occurrence of these behaviours (all of which are considered to be neutral with respect to teaching the nature of science) compared to the occurrence of the alternative response - "teacher gives direct answer to student's questions" is reflected in the teacher's domination of all the lessons in this setting - the teacher did most of the talking and told them what he wanted them to know; apart from the first lesson where the teacher gave a direct answer to a question by a student, the students did not ask questions during the lessons even though the teacher indicated in the initial interview that his students demonstrate above average participation in asking questions in his classes. Thus apart from giving direct answer to a single question asked by a student in the first lesson the teacher did not have the opportunity to use other alternative behaviours like "referring students questions back to students" because students did not ask questions during the lessons. Also from informal data collected during the laboratory settings and post lab settings and also during informal talk between the teacher

and his students, the teacher was observed to respond frequently to questions by giving a direct answer. It appeared therefore that this alternative behaviour comes more easily to the teacher than the other alternative behaviours which were not used by him.

5. Teacher distinguishes between fact and theory (A1)
6. Teacher stresses the tentative nature of knowledge in science (A2).
7. Teacher identifies any major unsolved problems in science (A5).

The teacher was not observed to "distinguish between fact and theory", "stress the tentative nature of knowledge in science" or "identify any unsolved problems in science" in any of the six lessons in this setting probably because the teacher did not consider the philosophical limitations of knowledge in science to be significant for the students. In lesson 1 (Table IV) where the teacher had as one of his objectives or intents, the recognition by the students of the "philosophical limitations and historical development of knowledge in science", only the historical aspect was emphasized. He talked about how the microscope was used by certain historical figures to obtain information about the microscopic world of plants but did not mention the philosophical nature of the knowledge obtained from the microscope and how one idea superseded the other. That is, the "tentative nature of knowledge in science" and "the distinction between fact and theory" were probably not

considered significant even though all these behaviours are considered to be consistent with teaching the nature of science.

8. Teacher encourages students to classify objects or structures (D4).
9. Teacher encourages students to state hypotheses (D6).
10. Teacher encourages students to use space/time relationship in explanation or description (D7).
11. Teacher encourages students to identify problems for possible investigation (D9).

These general behaviour patterns considered consistent with respect to teaching the nature of science (with the exception of item D4 above) were not used by the teacher in this setting. Students were not observed to "classify" objects or structures in all the lessons in this setting, a behaviour which probably reflects the nature of the topic for the lessons (Table III) and more significantly the way the topics were treated by the teacher in each of the six lessons. For example, in lesson 1 which dealt with the "historical development and use of the microscope in biology", the nature of the content dealt with does not lend itself easily to the classification of objects. No objects were provided for possible classification by the students. The main thrust of the lesson was to provide a historical account of the use of the microscope in biological work. Lesson 2 dealt with the "parts of the microscope" and involved learning the names of the different parts of the

compound microscope; this therefore does not require any grouping of objects.

Since as already mentioned, students did not contribute unsolicited information in class but only responded when they were asked to by the teacher, the students would "state hypothesis" or "identify problems for possible investigation" only when they were called upon to do that. But since the main thrust of the teacher's question as already explained was to direct students to "observe" and "name" objects and structures and did not include much higher order questions requiring students to "hypothesize" or "identify problems for possible investigation" these behaviours were not used in any of the lessons.

The use of "space/time relationships" in explanation or description by the students involves the use of complete sentences instead of single word statements to describe or explain phenomenon. This behaviour was not observed most probably because students' responses to teachers questions almost always involved the use of one or two word statements. This explanation is given further support by the observation that in answering the post lab questions in their lab report books most of the students wrote single word answers instead of complete sentences even after repeated warning by the teacher.

iii) Inconsistently Used General Behaviours.

From Table I and II and Fig. 2,7 the general behaviour pattern of the teacher as identified from behaviour items

which were used in some but not all lessons but which were found from the participant observation data to be a general characteristic of the teacher are as given below:

1. Teacher encourages students to explain why (causality) some phenomenon has occurred (B1 and D1).

This behaviour is considered to be consistent with the view of the nature of science used in the study and was observed to occur in all the lessons in this setting except the last two lessons - lessons 9 and 10. It is however considered to be a general behaviour of the teacher in this setting in that it is related to the "question-asking" behaviour of the teacher which even though infrequent, did occur in every lesson. Since this behaviour involves much thought on the part of the student (leading to a greater expenditure of time), its absence in the last two lessons seems to be partly a reflection of the "lack of time to cover the remaining topics" as expressed by the teacher at the end of lesson 7 and at the beginning of lesson 9. This probably caused the teacher to rush through the remaining topics in order to cover as many of them as possible. Also the non-occurrence of this behaviour in lesson 9 may be due to the short duration of this setting (9 minutes) in lesson 9.

2. Teacher asks students to speculate about future or past phenomena (B2).

The teacher was observed to ask students to "speculate" about some phenomenon (a behaviour considered consistent with

teaching the nature of science) in all lessons except lessons 7 and 9. This behaviour seems to be a characteristic of the question-asking behaviour of the teacher as explained above. Also the overall intent - the acceptance of scientific inquiry as a way of thought - seems to account for its use as a general behaviour. It was however, not observed in lessons 7 and 9 probably because of the fact that the duration of this setting in these lessons (Table I) were relatively short - 6 minutes in lesson 7 and 9 minutes in lesson 9.

3. Teacher encourages students to define new words used in the text (B3 and D2).

This behaviour, although considered to be a general behaviour of the teacher is regarded to be neutral with respect to the view of the nature of science used in this study. It is considered a general behaviour of the teacher even though it was not used in lessons 2 and 7, because its use depends on the "question-asking" behaviour of the teacher as explained above. But as any definition offered by the students rests on the teacher asking them to specifically define a concept, the non-occurrence of this behaviour in lesson 2 may be explained by the fact that lesson 2 was mainly a recap of lesson 1 and therefore did not involve any new concepts; the latter part of lesson 2 which involved identifying the parts of the microscope from a labelled drawing in the lab text did not involve any new words which had to be defined. Thus the way the topic was

treated in lesson 2 of this setting probably precluded the use of this behaviour-defining new terms - in lesson 2.

In lesson 7 even though new terminologies were encountered, the teacher chose to explain them himself, a behaviour conforming to the teacher's habit of "telling" students what they should know (i.e. teacher's domination of the setting). From a comment made by the teacher at the end of lesson 7 that he had realised that there were still too many topics to cover for the short time remaining for the rest of the term, it can be inferred that lack of time to cover the topics probably contributed to the teacher defining the new terms. It may also be that the duration of this setting (6 minutes) did not allow enough time for asking students to define any new terms encountered during the lesson.

In summarizing the general behaviour of the teacher in this setting, it can be said that the teacher tended to emphasize mostly low order student processes such as "observe", "name" and "define" and almost completely neglected the philosophical aspects of science. This behaviour seem to reflect on such factors as (1) the topics and the approach which emphasized content acquisition, (2) the dominating behaviour of the teacher (3) lack of time to cover the topics (4) the teacher's intent to get students to observe and measure some phenomenon and (5) the short duration of some of the lessons.

4.23 Situation Specific Behaviours of the Teacher

On examining Table I in conjunction with other participant observation data, the situation specific behaviours of the teacher as identified by items used in some but not all lessons were found to consist of the following :

1. Teacher encouraged students to relate newly introduced information to topic of discussion (D8) in the first lesson only.

Even though the teacher introduced new information into some of the other lessons, it was only in lesson 1 that the teacher specifically asked the students to relate it to the topic of discussion. In all the other lessons in which new information was introduced, the teacher used it to explain some phenomenon or concept. This reflects the dominating behaviour of the teacher - his tendency to tell his students everything. Also the examination of Table I reveals that the teacher had more time during lesson 1 (48 minutes) for discussion compared to the duration of the other lessons in this setting.

2. Teacher gave direct answer to student question (C4) in only the first lesson.

This behaviour is considered to be neutral with respect to the teaching of the nature of science and was observed only in lesson 1 where a single question was asked by a student. The infrequency of this behaviour in lesson 1 and its total absence in the other lessons in this setting may be considered consistent with the fact that students

were generally found not to ask quesitons during this setting. Clearly, this is in contradiction to the teacher's perception of his students as contributing unsolicited information in class and asking questions in class. It also reflects on the teacher's dominating behaviour in the setting.

3. Teacher emphasized the historical development of knowledge in science (A3) in only lesson 1, 2 and 7.

This behaviour was observed to occur only in lessons dealing in some way with the historical development of knowledge about the microscopic world of plants. Its use in lesson 1 most probably reflects the nature of the topic dealt with in this lesson, namely, "the historical development and use of the microscope in biology". During this lesson, the teacher used historical vignettes to show the use of microscope in identifying microscopic structures of the plant. Also the use of this behaviour in this lesson is consistent with one of the intents of the teacher during this lesson - that "students should recognize the philosophical limitations and historical background of science".

The behaviour was again used in lessons 2 and 7 because during both lessons, the teacher reviewed lesson 1.

4. Explanation of how information is obtained in science (A4) occurred only in the first two lessons of this setting.

The explanation of how information is obtained in science arose out of the discussion of the work done by the

historical figures used in lesson 1. The teacher explained how the microscope has been and is still used to identify the fine structures of the plant and micro-organisms. The behaviour was used in lesson 2 because the teacher reviewed lesson 1 during this lesson. However, it did not occur in lesson 7 even though the teacher reviewed lesson 1 in lesson 7. This is because in lesson 7 the entire setting took six minutes (Table I) and the review was done by asking only a couple of questions about the work of Robert Hooke. Thus probably this did not allow much time for using this behaviour in lesson 7. Both lessons 1 and 2 had relatively longer durations.

In summarizing the specific behaviour of the teacher it can be stated that the infrequent and specific behaviour of asking students to make high level process statements (like relating new information to topic), giving direct responses (answers) to student questions and emphasizing the history of science reflects on such varied prevailing factors as (1) the dominating behaviour of the teacher, (2) the short duration of the settings, (3) the un-questioning (non-inquisitive) attitude of the students, (4) the topics and the approach which emphasized content acquisition.

4.24 Setting Summary

In general, both specific and general behaviour patterns were used by the teacher in the developing text

material setting. The dominant general behaviour used by the teacher was to emphasize low order student processes such as "observe", "name" and "define" and almost totally neglect the philosophical limitations of science. Higher order student processes such as "stating hypothesis" and using "space/time relationships in explanation or description" were not encouraged. These behaviour patterns are consistent with prevailing factors such as (1) the dominating behaviour of the teacher, (2) the topics and approach used which emphasized content acquisition, (3) lack of time to cover topics (4) the teacher's intent to get students to observe and measure some phenomenon and (5) the short duration of most of the lessons.

The pattern of behaviour described above does not encourage students to ask many questions in class. Consequently the teacher has few opportunities to respond to student questions. On the few occassions when he did, in line with his general pattern of behaviour, he answered the questions directly rather than responding by using analogy, by referring back to students, by saying "I don't know but will find the answer for you"or by asking the students to find out the answer themselves.

The pressure of time that the teacher feels to cover a set number of topics does not allow him to encourage student use of high order processes. But on those occasions when he felt less pressure he did encourage the

use of such processes.

However, since the teacher's general behaviour pattern does not encourage the students to be inquisitive, on those occassions when he wanted them to be inquisitive he found it difficult to get them to respond appropriately.

Although the teacher did not emphasize the historical and philosophical nature of knowledge in science in his general teaching there were a few occasions on which the historical aspect of science was stressed as he felt that this would facilitate the student's understanding and appreciation of a particular topic. The introductory lesson to the Unit was the major occassion on which he was observed to use the entire class period to emphasize a historical topic. However, the time spent on this increased the pressure later on to get through the rest of the Unit with maximum efficiency.

4.30 PRE-LABORATORY SETTING

4.31 Introduction

This instructional setting was observed to occur on eight different occassions. It occurred in the second, third, fourth, fifth, seventh, eigth, ninth and tenth lessons of the ten lessons observed in the study. The teacher's behaviour in this setting was notably prescriptive - informing students about the investigation to be done

and its purpose. The only talking done by students was to respond to teacher's questions as in the Developing text material setting. Here too, students were not observed to contribute unsolicited responses. However, even though the teacher dominated the setting, generally he did not give step-by-step directions for the conduct of the investigation. This, as he explained, was to avoid unnecessary repetition and waste of time because the specific directions for each investigation were clearly given in the lab text and the students were capable of reading with understanding. During this setting and the laboratory and post lab settings the teacher followed the contents of the lab text closely - he restated the problem in the text and asked students to proceed with the investigation by following the directions in the text. Also during this setting, the teacher's "question-asking "behaviour became more infrequent - almost absent; this led to less student talk. It was also observed during the setting that the teacher did not repeat his own statements or ask students to repeat statements they had previously made concerning some phenomenon or object.

4.32 General Behaviour Pattern of the Teacher in the Pre-Lab Setting

As in the developing text material setting, the general behaviour patterns of the teacher were identified by examining the data in Tables V, VI and Fig. 3 for

TABLE V

Behaviour Items Observed Per Single Occurrences Of The Pre-Laboratory Setting On A Time Line

Lesson No.	Duration (minutes)	Behaviour Items Observed	Frequency of Observed Items
2	8	E4 T st prob to be invest	2
		E6 T condt dem rel to invest thme	1
		F1 T demon use of app or equip	1
		F2 T disc pot'l diff in lab pro	2
		F5 T aks S to prep wrt rep of invest	2
		F6 T mk st abt saf prec	2
		H1 S proc w invest w/o dir fr T	1
3	2	E4 T st prob to be invest	2
		H1 S proc w invest w/o dir from T	1
4	6	E4 T st prob to be invest	1
		H1 S proc w invest w/o dir from T	1
5	15	E4 T st prob to be invest	3
		F1 T demon use of app or equip	1
		F2 T disc pot'l diff in lab pro	1
		F3 T exp hw to mk meas	5
		F4 T exp hw to wk math prob	5
		H3 S req clar of lab dir	1
7	15	E3 T aks S to rel invest prev wk	2
		E4 T st prob to be invest	3
		E6 T condt dem rel to invest thme	1
		F1 T dem use of app or equip	1
		F2 T disc pot'l diff in lab pro	1
		F3 T exp hw to mk meas	1
		F4 T exp hw to wk math prob	1
		G3 S rel invest to prev wk	2
		H1 S pro w invest w/o dir from T	1
8	8	E2 T aks S to st pur of invest	1
		E4 T st prob to be invest	2
		E5 T rel invest to pre wk	1
		F2 T disc pot'l diff in lab pro	1
		F5 T aks S to prep wrt rep of invest	1
		F6 T mk st abt saf prec	2
		H1 S proc w invest w/o dir for T	1
		G2 S st purp of invest	1

continued...

TABLE V - (continued)

Lesson No.	Duration (minutes)	Behaviour Items Observed	Frequency of Observed Items
9	12	E4 T st prob to be invest	1
		E6 T condt dem rel to invest thme	1
		F1 T dem use of app or equip	1
		F5 T aks S to prep wrt rep of invest	1
		F6 T mk st abt saf prec	4
10	5	F2 T disc pot'l diff in lab pro	1
		F3 T exp hw to mk meas	1
		F4 T exp hw to wk math prob	1
		F5 T aks S to prep wrt rep of invest	1

TABLE V - (concluded)

TABLE VI

Summary of Observations for the Pre-Laboratory Setting as Recorded on the Modified Instrument

Number of Times Setting was Observed : 8

	Behaviour Items	No. of Settings Behaviour Occurred	Frequency of Behaviour
E0	TEACHER: IDENTIFICATION OF PROBLEM FOR INVESTIGATION		
E1	Teacher asks students to state problem to be investigated	-	-
E2	Teacher asks students to state purpose of the investigation	1	1
E3	Teacher asks students to relate investigation to previous work	1	2
E4	Teacher states problem to be investigated	7	14
E5	Teacher relates investigation to previous work	1	1
E6	Teacher conducts investigation relevant to investigation theme	3	3
E7	Teacher asks students to form hypothesis for investigation	-	-
E8	Teacher states hypothesis for investigation	-	-
E9	Teacher asks students to operationalize variables in the hypothesis	-	-
F0	TEACHER: DIRECTIONS ON CONDUCT OF THE INVESTIGATION		
F1	Teacher demonstrates use of apparatus or equipment	4	4
F2	Teacher discusses potential difficulties in lab procedure	5	6
F3	Teacher explains how to make measurements	3	7
F4	Teacher explains how to work mathematical problems	3	7
F5	Teacher asks students to prepare a written report of the investigation	4	5
F6	Teacher makes statement about safety precautions	3	8

continued...

TABLE VI - (continued)

Behaviour Items	No. of Settings Behaviour Occurred	Frequency of Behaviour
GO STUDENT:IDENTIFICATION OF PROBLEMS FOR INVESTIGATION		
G1 Student restates investigation theme described by teacher	-	-
G2 Student states purpose of the investigation	1	1
G3 Student relates investigation to previous work	1	2
G4 Student states own problem for investigation	-	-
G5 Student states hypothesis for investigation	-	-
G6 Student proposes operational definitions for variables in the study	-	-
HO STUDENT: DIRECTIONS ON CONDUCT OF INVESTIGATION		
H1 Student proceed with investigation without direction from the teacher	5	5
H2 Student reads alound directions for investigation	-	-
H3 Student requests clarification of lab directions	1	1

TABLE VI - (concluded)

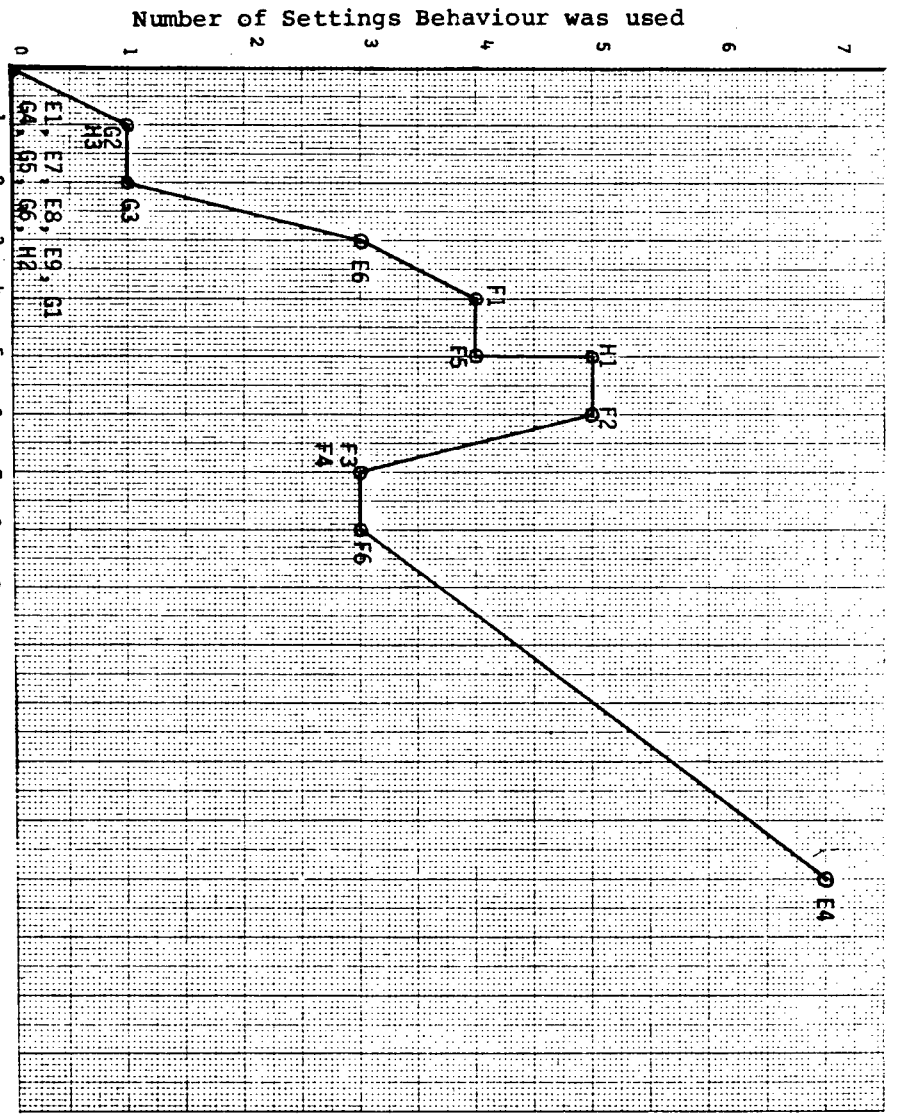

Figure 3. Item Frequency Against Number of Settings Behaviour was used in Pre-Laboratory Setting

the pre-lab setting.

i) Consistently Used General Behaviours. Following a similar procedure, it can be seen from Tables V and VI and Fig. 3, that no behaviour item was used consistently in all the lessons in this setting.

ii) Unused General Behaviours. From Tables V and VI and Fig. 3, the general behaviour pattern of the teacher as identified from behaviour items not used in any of the lessons in this setting were:

1) In identifying problems for investigation, teacher asks students to state the problem for investigation (E1).

Students were never observed to identify and state the problem for investigation despite the fact that the investigations were clearly given in the lab text used by both the teacher and the students and can therefore be identified by the students. This may be due to the prescriptive behaviour of the teacher during that setting - that of telling the students everything they need to know about the investigation. By not asking the students to state the problem for the investigation, the teacher missed opportunities to engage in a behaviour considered to be consistent with teaching the nature of science. It is also possible that this behaviour did not occur in

this setting because the teacher was convinced that "students at this level need to be given every guidance in conducting laboratory investigations".

2. Teacher states hypothesis or ask students to state hypothesis and operationalized variables for the investigation (E7, E8, E9, G5, G6).

Neither the teacher nor the students were observed to state hypotheses and supply operational definitions for variables in the investigation even though these behaviours are considered consistent with teaching the nature of science. This might be due to the structure of the lab text used by the teacher and the students. The text material delineates the investigations to be done and provides step-by-step directions integrated with procedural questions aimed at focusing students' observations and understanding. In addition graded questions are provided after each investigation (Post-investigation questions) to reinforce students understanding of the investigations. However, the text does not identify or provide statements of hypothesis or definition of variables. Since the teacher adhered closely to the contents of the lab text, the absence of these behaviours in his normal teaching can probably be accounted for by the absence of hypothesis statements or operational definitions in the text. Looked at in a slightly different way, another plausible reason could be that the nature of most of the topics in this

setting such as "operation and care of the microscope", "observation of living and non-living cells", "observation of human blood cells" and "observing the various kinds of cells in a leaf" and the approach used in the text do not lend themselves readily to the use of these behaviour items - hypothesizing and defining operationally by the teacher.

3. Teacher encourages students to restate investigation theme described by him (G1).

Since during this setting, students were observed to talk only when they were asked a question, the fact that students were never observed to restate the investigation theme described by the teacher in all the lessons could be ascribed to the very few questions (three) asked by the teacher. Apart from the fact that the teacher was not observed to ask the students at any time during the setting to restate the investigation theme, the teacher's frequent statements concerning the large number of "topics to be covered in the short time remaining for the rest of the term", probably explains the absence of this behaviour item. That is, the occurrence of this behaviour would have been just a sheer waste of time because it would have meant repeating a statement already made by the teacher, a behaviour considered inconsistent with the teaching of the nature of science.

4. Teacher encourages students to state their own problems for the investigations (G4).

Although students' identification of their own problems for investigation is considered to be consistent

with teaching the nature of science, they were never observed during this setting to investigate their own problems. This might be due to the teacher's close adherence to the lab text which delineates all the investigation to be done by the students.

5. Teacher encourages students to read aloud directions for investigation in the lab text (H2).

Students were never observed to read aloud the directions for investigation during this setting. This might be explained thus: Because of the teacher's frequent complaints about the limited time left for covering the remaining topics in the course, he probably regarded the reading of the investigation directions during this setting as a waste of time. The students were always observed to read the directions during the laboratory setting. The reading aloud of directions (a behaviour considered neutral with respect to teaching the nature of science) might probably be used in a class where the students don't have sufficient lab texts and where the students are perceived to be of low academic ability. However, in this study, each of the students had one lab text and were perceived by the teacher to be ranging from average to bright in academic ability.

iii) Inconsistently used General Behaviours.

From Table V, the general behaviour pattern of the teacher as identified from the behaviour items used in some but not all lessons but which were found from the informal data to be

a general characteristic of him were:

1. Teacher identifies problems for possible investigation (E4).

The teacher was generally observed to identify the problem for investigation in each lesson, a behaviour considered inconsistent with teaching the nature of science. This reflects the teacher's dominating behaviour and the fact that he was convinced that students at this level need all the guidance necessary for carrying out the investigations successfully. However, in lesson 10, this behaviour was not observed mainly because in the preceding developing text material setting during the same lesson the teacher stated the problem to be investigated by the students. However this could not be coded in the prelab setting because it did not occur in this setting.

The above behaviour occurred in the developing text material setting of lesson 10 because of the approach used by the teacher in treating the topic - "the internal structure of a leaf" during that setting. During the Developing text material setting, the teacher very frequently referred to what the students were supposed to observe during the investigation - "observing the various kinds of cells in a leaf" thus establishing some strong link between the developing text material setting and the prelab setting. This link was not observed in lesson 9 where similar topics were treated in the developing text material setting and prelab setting or in lessons 2 and 7

where a developing text material setting immediately precedes a prelab setting. Thus because of the approach used by the teacher during lesson 10, he did not probably see the need to distinguish mentally between the developing text material and pre-lab settings in this lesson but assumed that since he had stated the problem already, there was no need for a restatement.

2. Teacher encouraged students to proceed with investigation without direction from the teacher (H1).

Students were observed in almost all the lessons to proceed with investigation without specific directions from the teacher, a behaviour considered consistent with teaching the nature of science. However, even though the teacher did not give step by step directions for conducting the investigation the lab text did provide the needed directions. Thus the students did not use their own individual procedures for carrying out the investigations. The teacher probably avoided repeating the instructions in the text to save time. This probably explains why this behaviour was observed in most of the lessons and why it is considered as a general behaviour of the teacher. However, the behaviour was not observed in lessons 5, 9, and 10 where the teacher stated the step by step directions for the conduct of the investigations in the lab text. The teacher mentioned during the pre-lab settings of these lessons that it was difficult to get very good results if

the procedure were not followed closely. For example in lesson 9 which dealt with the identification of the student's own blood cells, the teacher went further to prepare a demonstration slide which the students could use if they failed to get a good slide themselves; and in lesson 10, the students were provided with commercially prepared slides of the cross-section of a leaf to draw from after they have tried mounting sections on their own.

3. Teacher asked students to prepare written reports of the investigations (F5) in only lessons 2,8,9 and 10 of this setting.

Apart from its use in the very first lesson which involved laboratory investigation (lesson 2) this behaviour was not used in the succeeding four lessons in this setting most likely due to the teacher's perspective of his students as hardworking, and always doing assignments given to them.

In lesson 2 - "operation and care of the microscope" which started off the series of labs, the teacher made the first general statement that students "should write report of all the investigations to be done from now on,..... this will involve answering the black questions in the procedure and the actual lab (post-investigation) questions in complete sentences,..... your written reports will be collected later on ....." The teacher was convinced from this general statement that the students would do as told since he saw them as being hardworking

and always did assignments given to them. Thus he probably saw no need to repeat the instructions or expectations in the lessons immediately following lesson 2.

However, the behaviour was observed in lesson 8 where the teacher reminded the students that the lab reports for the investigations carried out so far would be collected at the end of next lesson, lesson 9.

In lesson 9, the teacher told the students to include a report of the investigations to be done during the laboratory setting of lesson 9. In lesson 10, that behaviour was again used by the teacher because after going through (i.e. marking) the reports, the teacher noticed that many of the students "did not write the report the way I asked you to; most of you just wrote one word answers to the questions". He emphasized that since the lab reports would serve as their notes from which they could review the concepts dealt with, they should be written in meaningful form.

In summary, it can be stated that no hypothesis statements were made in any of the investigations, the teacher generally identified the problems for investigation and asked the students to follow the investigation procedures in the text and prepare written reports of the investigations. These general behaviours seem to reflect such factors as (1) the dominating behaviour of the teacher, (2) the structure of the lab text which is prescriptive in defining the problem and procedure

for investigation and which does not allow for the statement of alternative hypotheses, (3) lack of time and pressure to complete a large number of topics in a short time and (4) the teacher's perception of his students as hardworking.

4.33 Situation Specific Behaviour Pattern of the Teacher During this Setting

From Table V, the situation specific behaviour patterns of the teacher as identified by items used in some but not all lessons were as follows:

1. Teacher encouraged students to state purpose of investigation (E2, G2) in only lesson 8.

This behaviour is considered consistent with teaching the nature of science in this setting but was not observed in almost all the lessons because of the teacher's prescriptive behaviour. The teacher was observed to identify the problem and state the purpose of the investigation in an attempt to give maximum guidance to the students in the conduct of the investigation. However, its occurrence in lesson 8 could be rationalized as follows: Lesson 8 which dealt with "observing living and non-living plant cells" was a continuation of lesson 7 which the student could not finish because of lack of time. During lesson 7, the teacher identified the problem and stated the purpose of the investigation but encouraged students to relate the investigation to some previous work. However, since lesson 8 was a continuation

of the investigation in lesson 7, the teacher chose to ask the students to restate the purpose stated by him in previous lesson instead of repeating it himself. This kind of behaviour occurred after almost every laboratory lesson, i.e. during the post lab settings when the teacher always asked the students to state the purpose of the previous lab investigation probably as a way of checking their understanding.

2. Teacher encouraged students to relate investigation theme to previous work (E3,G3) in lesson 7.
3. Teacher related the investigation theme to previous work (E5) in only lesson 8.

Although these two behaviours are considered consistent with the teaching of the nature of science, they were not observed to be general behaviours of the teacher. Both the teacher and the students were not observed to relate the investigation to previous work probably because the lab text which the teacher adhered to, does not specifically state the link between different investigations.

However, the teacher did ask a student to relate the investigation in lesson 7 - "observation of living and non-living plant cells" to previous work done in the elementary grade levels on food tests. Specifically, the teacher encouraged students through asking a question to relate the staining technique in the investigation to the

identification of starch in food substances with iodine to give a blue-black coloration. This occurred because the teacher indicated that "the technique of staining used to differentiate the cells in a plant is similar to the identification of starch" which the students were familiar with. But in lesson 8, the teacher established the relation himself by referring to the starch test already discussed in lesson 7. He used this behaviour in lesson 8 because he discovered during the preceding laboratory work in lesson 7 - "observation of living and non-living plant cells" that students did not seem to grasp the significance of staining in differentiating cells.

4. Teacher conducted demonstration relevant to investigation theme (E6) in only lessons 2,7 and 9.

This behaviour (considered consistent with teaching the nature of science) is identified as a situation specific behaviour of the teacher in the pre-lab setting in that it occurred only when the teacher envisaged possible difficulties to be encountered by the students during the investigation due to the high level of manual skills involved. The acquisition of skills in the use of the microscope by the students was of prime importance to the teacher as he indicated in all the 8 lessons in this setting that the "students should acquire specific science related manual skills" (Table IV). The teacher emphasized every now and then during post lesson conversation that he wanted his students "to be able to use

the microscope correctly, including the technique of cutting sections, staining, mounting slides and drawing from the microscope".

The teacher's indication of the difficulties of certain investigations probably stemmed from his long experience in teaching this course over a number of years. Thus to make sure that at least students became familiar with the required manipulatory skills involved in an investigation, the teacher performed demonstrations whenever he came to one of the "difficult" investigations. He indicated that he did this in order to avoid a lot of procedural questions during the lab setting. According to the teacher, he would have preferred to treat each "difficult" investigation in two or three lessons to get the student to acquire the skills required but "there is no time".

In lesson 2 - "operation and care of the microscope" - which was the first lesson in this setting, the teacher performed part of the investigation for the students to demonstrate the proper use of the microscope probably in order to safeguard against possible breakages since this was "the first time that students are actually going to learn how to use the microscope".

Lesson 7 "observation of living and non-living plant cells" was the first investigation which involved cutting their plant sections with a razor blade (instead of a

microtome) and staining for observation under the microscope. Because of the difficulty in getting very thin sections with the razor blade, the teacher demonstrated this technique.

The "observation of human blood cells" in lesson 9 involved the students in observing their own blood cells under the microscope. Teacher envisaged difficulties in getting a good blood smear on the slide, in using the sterile lancet, and in using the staining technique specified if the instructions were not strictly adhered to. He therefore went through the entire investigation with the students with the result that a "masterpiece" blood slide was produced which the students could refer to.

5. Teacher demonstrated the use of apparatus (F1) in only lessons 2, 5, 7 and 9.

This behaviour was observed only where the investigation involved the use of new techniques such as proper handling of microscope, as in lesson 2, reading the millimetre scale under the microscope as in lesson 5, cutting sections for mounting and staining on a slide as in lessons 7 and 9 respectively. It arose as a necessary component of conducting demonstrations where some "difficulty" was envisaged with some investigations - that is, in lessons 2, 7 and 9 as explained previously. It however occurred in lesson 5, "magnification with the microscope" because this lesson involved observing the millimetre markings on the edge of

a plastic ruler to determine the diameter of the low power, medium power and high power fields of the microscope, a new technique for the students. There was therefore the danger of students attempting to observe the ruler with the high power objective lens and therefore destroying the lens. The teacher therefore showed how the ruler should be used to determine the field diameter for the three fields.

6. Teacher discussed the potential difficulties in the lab procedure (F2) in lessons 2,5,7,8 and 10 and not at all in the other lessons.

Although this behaviour is considered consistent with teaching the nature of science and was used in five out of the eight lessons in this setting, it is still considered to be a situation specific behaviour of the teacher. This is because it was observed mainly during the discussion of investigations which involved the use of new techniques - lessons 2,5 and 7 as explained above, and lessons which involved cutting thin sections of a plant with a razor blade as in lessons 7, 8 and 10.

This behaviour occurred in lesson 8 because students complained during the laboratory setting of lesson 7 of not being able to get thin sections for observation.

It was observed again in lesson 10 which dealt with "observing the various kinds of cells in a leaf"; this also involved cutting thin sections of plant leaf for staining and observation.

7. Teacher made statements about safety precautions to be exercised in the investigations (F6) in lessons 2,8 and 9 only.

Warning students about possible dangers inherent in the investigations is considered consistent with teaching the nature of science. However its occurrence in this setting is considered to be situation specific in that it was observed only when there was the likelihood of using hazardous or delicate materials in the investigations as in lessons 2,8 and 9.

In lesson 8 which was a continuation of lesson 7, the teacher asked students to use additional reagents such as phloroglucinol for staining the cross sections of the plant materials cut by the students, and pure alcohol for dehydrating the cells. However, since the phloroglucinol is prepared in alcohol and is therefore highly inflammable on direct contact with flame just as pure alcohol is, the teacher advised the students to keep the reagents away from flame. The teacher also warned the students to refrain from drinking the alcohol because it contained toxic substances.

In lesson 9 students had to prepare smears of their own blood on a slide and observe it after staining, under the microscope. Teacher warned that in such investigations, students were to avoid exchanging used lancets in punching their fingers to prevent possible transfer of blood diseases

such as nucleosis. Other precautions taken in this lesson involved warning students who were haemophiliacs from punching their fingers because of possible profuse bleeding.

The behaviour was also observed in lesson 2 because the teacher indicated his concern about the microscope as follows:

Teacher: *The microscope is (highly) expensive and delicate. You are a lucky group to have the opportunity to use these microscopes, the best in the school....., however never forget to carry the microscope around by placing one hand at the bottom.....with the other hand holding the arm. Why should you do this?*

Student: *To avoid dropping it.*

Teacher: *Also I don't want you to use the high power objective lens indiscriminately. .....(otherwise you may) knock it against a slide thereby destroying the lens.*

8. Teacher explained how to make measurements (F3) in lessons 5, 7 and 10.

9. Teacher explained how to work mathematical problems (F4) in lessons 5, 7 and 10 only.

These two behaviours considered to be consistent with teaching the nature of science occurred only in the pre-labs to laboratory investigations involving the uses of mathematical calculations to arrive at the magnification of a drawing made from the observation of a slide under the microscope. That is, the occurrence of these behaviours

was related to the nature of the topic for the lesson.

Lesson 5, which dealt with "magnification with the microscope" was the first lesson in this setting which involved the discussion of microscope constants and object magnification. That is, it is the first prelab setting whose laboratory setting involve the manipulation of numbers to arrive at the microscope constants. The teacher therefore explained how to make the measurements and compute the constants from the field diameter.

This concept was transferred to both lesson 7 and lesson 10 where the procedure in the lab text called for the specification of the magnification of any drawings made by the students. The teacher explained how to proceed to get the correct measurements through asking students to recall the procedure used in lesson 5.

These behaviours were not observed in lessons 8 and 9 because lesson 8 was a continuation of lesson 7 so probably there was no need to restate how the measurements and mathematical computations should be done; and it was not observed in lesson 9 because even though the procedure in the text asked for accurate drawing and the identification of the magnification of their drawing, the teacher asked the students to make only sketches of the blood cells and not bother about indicating the magnification; the teacher asked the students to do this mainly because he realised that there was not enough time (only 11 minutes) for the students to complete the investigation

during the laboratory setting.

11. Student requested clarification of lab directions (H3) in only lesson 5.

This behaviour, though consistent with the teaching of the nature of science, was observed to be absent in almost all the lessons with the exception of lesson 5. This might be due to the fact that students read the step by step directions given in the lab text only during the laboratory setting and not during the prelab setting or even before the prelab setting. Thus, without reading the assignment before or during the prelab setting, the students would not be able to identify and question the teacher on the "not-so-clear" steps in the procedure.

The behaviour was however observed in lesson 5 because it was during this lesson that teacher tried to explain the procedures involved in computing the magnification of drawings made under the microscope and computing the microscope constant from the field diameter; the mathematics involved was a bit confusing to the students and this prompted one of them to ask the teacher to provide further clarification. In sum, occassionally, the teacher asked the students to identify some aspects of the problem for investigation such as its purpose or its relation to other investigations, conducted demonstrations and identified constraints in the investigations. On other occassions, he related the investigation to previous work (and barely encouraged students

to ask questions about the investigation procedure).

The occasional use of these behaviours seems to be consistent with such factors as (1) the dominating behaviour of the teacher, (2) the difficulty of the techniques involved in the investigations as perceived by the teacher, (3) the mathematical nature of the topics, (4) the hazardous or delicate nature of the materials used in the investigation, (5) the lack of time to complete topics which is reflected in the teacher's technique of asking students to read the investigation directions only during the lab setting, and (6) the teacher's technique of not repeating his own statements and of not asking students to repeat statements they had previously made concerning a phenomenon.

4.34 Setting Summary

From the above analysis of the behaviour pattern contributing to the teaching of the nature of science during the teacher's normal day to day teaching, it can be concluded that just as in the developing text material setting, the teacher generally uses both recurrent behaviours and situation specific behaviours in this setting. The dominant general or recurrent behaviours of the teacher in this setting was to identify the problems for investigation and ask the students to follow the investigation procedures and prepare written report of their investigations; no hypothesis was provided for any of the investigations.

The occurrence of these recurrent behaviours seem to be consistent with such factors as (1) the dominating behaviour of the teacher, (2) the structure of the lab text which is pprescriptive and does not allow for the statement of hypotheses, (3) lack of time to complete topics, (4) and the teacher's perception of his students as hardworking. These recurrent behaviours of the teacher did not encourage students to participate well in this setting; the teacher completely dominated the setting. Thus it was only on certain occasions that the students had the chance to make some contributions during the setting. Thus, in line with his technique of not repeating his own statements and asking students to repeat their statements, the teacher related the investigation to previous work and also asked the students to identify some aspect of the problem such as its purpose or its relation to other investigations. Occasionally when the techniques or mathematical computations involved in carrying out the investigations were perceived by the teacher to be difficult (a reminiscence of his dominating behaviour) and when the nature of the materials used were such that precautions had to be taken, the teacher always conducted demonstrations including mathematical calculations and identified the precautions involved. Also reading the investigation procedures only during the laboratory setting did not give the students much chance

to ask questions on the procedures during this setting. On the only occasion when the students had the chance they asked for the clarification of certain parts of the directions.

4.40 LABORATORY SETTING

4.41 Introduction

The laboratory settings were observed on eight different occassions. They occurred in lessons 2,3,4,5, 7,8,9 and 10 of the ten lessons observed in this study. The most consistent behaviour observed in this setting was the involvement of students in carrying out the investigations themselves and the assessment of students understanding of the investigations through a series of questions asked by the teacher as he moved from one working group to another. The students asked many questions both procedural and non-procedural questions in this setting although only the procedural ones were coded by the instrument. Thus this setting was mainly dominated by the students; however, frequently, the teacher exhibited his usual tendency as seen in the developing text and pre-lab settings of telling students things they should know - a behaviour consistent with his general intent of teaching students to "learn specific course content". During this setting some students worked in groups while two students worked on their own. The groups were formed by the students themselves and the average number of students in a group

was three. There were sufficient materials available for the students to use during the investigations - there were twelve working compound microscopes available to the students and each working group was made to sign out one of the microscopes for the rest of the term.

During the setting, the teacher and the students followed the contents of the lab text closely, i.e. the procedures laid out in the text and the sequencing of the topics. However, in lessons 9 and 10, the teacher reversed the sequence of the topics because of a change in the time table brought about by the signing up of students to tutors during the time that lesson 9 was observed. During the signing-up week the total number of periods per day was increased from five to six and the duration of each period was reduced to about 45 minutes from the normal 60 minutes. Because of this change, the teacher chose to treat the topics he believed required shorter time to complete. Thus he treated "preparation and observation of human blood cells" in lesson 9 instead of the "observation of the various kinds of cells on a leaf" which he later treated in lesson 10.

The teacher also used this setting to talk about topics not directly related to the investigations the students were doing. For example he asked students to observe a mosquito pond in the lab and discussed the hatching of the mosquito larvae. He also mounted a slide

of the pond water from the mosquito pond and asked students to observe the diatoms and other organisms.

The topics for the various lessons in this setting are as given in Table III.

4.42 General Behaviour Pattern of the Teacher in the Laboratory Setting

Following the procedure used in the developing text material and pre lab settings, this behaviour pattern was identified by examination of similar data (Tables VII and VIII and Fig. 4) for the laboratory setting.

i) Consistently Used General Behaviours

From Tables VII and VIII and Fig.4, the general behaviour patterns of the teacher as identified by the behaviour items used consistently in all the lessons were:

1. Teacher encourages students to make their own observation (L1).

The involvement of students in doing the experiments themselves - observing blood cells, or the cells in a plant - probably reflects the teacher's perception of his students as "enjoying doing science", "enjoying carrying out experiments in science" and also participating fully in his classes.

The use of this behaviour may also be consistent with the intents of the teacher for the lessons in this setting. In all the lessons, the teacher indicated that the "students should observe and measure" some phenomenon or

TABLE VII

Behaviour Items Observed Per Single Occurrences Of The Laboratory Setting On A Time Line

Lesson No.	Duration	Behaviour Items Observed	Frequency of Items
2	22	I1 T aks S to obs sm obj or phen	1
		I2 T aks S to des sm obj or phen	5
		I3 T aks S to exp why or hw sm phen occd	1
		I4 T exp why or hw sm phen occd	1
		J3 T ref ques abt invest proc kb to S	3
		J4 T gvs dir ans abt invest proc	5
		J5 T per pt of invest f S in res to ques	3
		K2 T aks ldg ques to eval wk	15
		K3 T mvs fr sta-t-sta	*
		L1 S ki own obs	*
		L2 S aks T f hlp w invest proc	5
3	12	I4 T exp why or hw sm phen occd	1
		J2 T ans S ques abt invest proc w anlgy	1
		J4 T gvs dir ans abt invest proc	3
		K2 T aks ldg ques to eval wk	10
		K3 T mvs fr sta-t-sta	*
		L1 S mk own obs	*
		L2 S aks T f hlp w invest proc	5
4	35	I1 T aks S to obs sm obj or phen	10
		I2 T aks S to des sm obj or phen	2
		I4 T exp why or hw sm phen occd	7
		J1 T res to S ques w pro f ans ques	2
		J3 T ref ques abt invest proc bk to S	2
		J4 T gvs dir ans abt invest proc	6
		J5 T per pt of invest fr S in res to ques	1
		K2 T aks ldg ques to eval wk	29
		K3 T mvs fr sta-t-sta	*
		L1 S mk own obs	*
		L2 S aks T fo hlp w invest proc	9

continued....

TABLE VII (continued)

Lesson No.	Duration	Behaviour Items Observed	Frequency of Items
5	16	I2 T aks S to des sm obj or phen	6
		I4 T exp why or hw sm phen occd	1
		J1 T resp to S gves w pro f ans ques	2
		J3 T ref ques abt invest proc bk to S	1
		J4 T gvs dir ans abt invest proc	1
		J5 T per pt of invest f S in res to ques	1
		K2 T aks ldg ques to eval wk	17
		K3 T mvs fr sta-t-sta	*
		L1 S mk own obs	*
		L2 S aks T f hlp w invest proc	5
7	29	I1 T aks S to obs sm obj or phen	4
		I2 T aks S to des sm obj or phen	2
		I4 T exp why or hw sm phen occd	4
		J1 T res to S ques w pro f ans ques	1
		J3 T ref ques abt invest proc bk to S	1
		J4 T gvs dir ans abt invest proc	9
		J5 T per pt of invest f S in res to ques	3
		K2 T aks ldg ques to eval wk	14
		K3 T mvs fr sta-t-sta	*
		L1 S mk own obs	*
		L2 S aks T f hlp w invest proc	12
8	44	I1 T aks S to obs sm obj or phen	5
		I4 T exp why or hw sm phen occd	8
		J1 T resp to S ques w pro f ans ques	1
		J3 T ref ques abt invest proc bk to S	1
		J4 T gvs dir ans abt invest proc	13
		J5 T per pt of invest f S in res to ques	2
		K2 T aks ldg ques to eval wk	18
		K3 T mvs fr sta-t-sta	*
		L1 S mk own obs	*
		L2 S aks T f hlp w invest proc	14

continued...

TABLE VII (continued)

Lesson No.	Duration	Behaviour Items Observed	Frequency of Items
9	11	I1 T aks S to obs sm obj or phen	3
		K2 T aks ldg ques to eval wk	4
		K3 T mvs fr sta-t-sta	*
		L1 S mk own obs	*
		L3 S prep wrt rep of invest	*
		L2 S aks T f hlp w invest proc	2
10	22	I1 T aks S to obs sm obj or phen	2
		J4 T gvs dir ans abt invest proc	8
		K2 T aks ldg ques to eval wk	5
		K3 T mvs fr sta-t-sta	*
		L1 S mk own obs	*
		L2 S aks T f hlp w invest proc	7

TABLE VII (concluded)

TABLE VIII

SUMMARY OF OBSERVATIONS FOR THE LABORATORY SETTING AS RECORDED ON THE MODIFIED INSTRUMENT

NUMBER OF TIMES SETTING WAS OBSERVED : 8

	BEHAVIOUR ITEMS	No of Settings Behaviour Occurred	Frequency of Behaviour
I0	TEACHER:IDENTIFY CRITICAL ASPECTS OF THE INVESTIGATION		
I1	T asks student to observe some object or phenomena	6	25
I2	T asks student to describe some object or phenomena	4	15
I3	T asks student to explain why (causality) or how (mechanics) some phenomenon occurred	1	1
I4	T explains (causality) or how (mechanics) some phenomenon occurred	6	22
J0	TEACHER:RESPONSE TO STUDENT QUESTION ABOUT INVESTIGATION PROCEDURE		
J1	T responds to student question about procedure by suggesting a process for answering questions	4	6
J2	T answers student question about investigation with an analogy	1	1
J3	T refers student question about investigation procedure back to student	5	8
J4	T gives direct answer to student question about investigation	7	45
J5	T performs part of investigation for student in response to question about procedure	6	10
K0	TEACHER-EVALUATION		
K1	T grades students on lab procedure as the work	-	-
K2	T asks leading questions to evaluate students work	8	112
K3	T moves from station to station	8	*
L0	STUDENT:IDENTIFY CRITICAL ASPECTS OF THE INVESTIGATION		
L1	S make own observations	8	*
L2	S asks teacher for help with investigation procedure	8	59
L3	S prepare a written report of the details and results	1	*

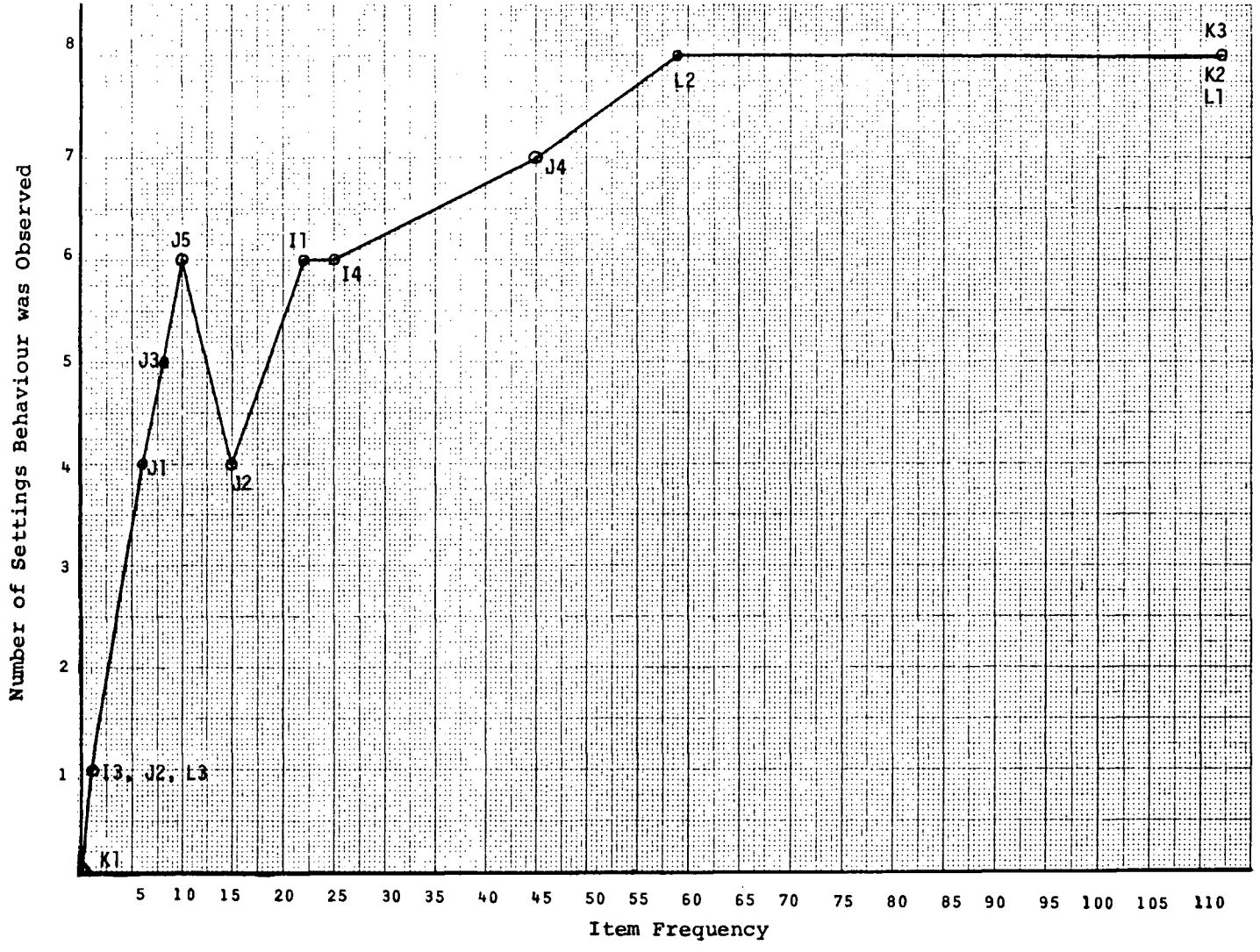

Figure 4. Item Frequency Against Number of Settings Behaviour was used in Laboratory Setting

"acquire specific science-related manual skills",or both (both objectives occur in the overall intents of the teacher). To achieve these objectives or intents, students should be encouraged to do the investigations themselves as was done by the teacher in this study.

2. Teacher asks leading questions to evaluate the student's understanding of the investigation (K2)
3. Teacher moves from station to station to give attention to individual working groups (K3).

These behaviours are considered to be consistent with teaching the nature of science and were observed to be used both frequently and consistently throughout the study. The teacher moved around the groups asking questions to assess the students' understanding of both the procedure and the specific content to be learned in the investigations and explaining some phenomenon to them. However not much movement was done in lesson 3 where the teacher got tied up with setting up a lab test for his grade 9 group. The teacher's intent for each lesson that "students should acquire specific science-related manual skills", specifically the techniques of microscopy, and his overall intent - that"students should learn specific course content", probably contributed to the teacher's movement around the groups, together with his question asking and his explanation of some phenomenon to the students.

4. Teacher encourages students to ask for help with investigation procedure (L2).

The teacher's indication that his students "ask questions" and "contribute unsolicited ideas" apply in this instructional setting where students were observed to demonstrate this behaviour rather profusely. Some of the student's questions asked for help with the investigation procedure while others were geared to understanding of the course content. It could be argued that the occurrence of this behaviour as a general behaviour in this setting reflects on the teacher's approach to the handling of the pre-laboratory settings. That is during or before the prelab setting students were not encouraged to read the directions for the investigations and ask questions on any "knotty" points in the directions. The only time students read the directions was during the laboratory setting. Thus, after reading the procedure, the students call on the teacher to help them with the "knotty" points in the directions. However, there were instances where some students asked the teacher for help with the investigation without taking their time to read through the directions carefully.

Thus both the teacher's perception of his students and his approach to the prelab contributed to the use of this behaviour in this setting. This behaviour is however considered neutral with respect to teaching the nature of science.

ii) Unused General Behaviours

The teacher's general behaviour as identified from

items not used in any of the lessons as seen in Table VIII and Fig.4 was:

1. Teacher grades students on lab procedure as they work (K1).

The teacher was not observed in all the lessons to grade students on lab procedures. The teacher did not require the students to write out the procedures because they were already laid out in the lab text. Therefore students were not graded on lab procedures even though this behaviour is considered to be consistent in teaching the nature of science.

iii) Inconsistently Used General Behaviours.

The general behaviour patterns as identified by behaviour items used in some but not all lessons but which were considered from the informal data collected during the study to be general behaviour pattern of the teacher (Table VII and Fig.4) were:

1. Teacher asks students to observe some object or phenomenon (I1)

This behaviour occurred any time the teacher moved from one working group to another and at times when he found a particularly good slide prepared by a student or when he performed part of the investigation in answer to a student question for help. It was the teacher's general behaviour to move from one group of students to

another explaining some content and asking questions most of which always required the student to observe some object or phenomenon.

The use of this behaviour in almost all the lessons also reflects on the nature of the investigations (topics) dealt with in the eight lessons in this setting (Table III). The topics required the observation of slide preparations of a plant part as in lessons 7,8 and 10 or blood cells as in lesson 9 or the observation of the millimeter scale on a plastic ruler as in lesson 5, the depth of field of a thread as in lesson 4 or the observation of the letters and dots in a newspaper as in lessons 2 and 3. Thus the teacher had the opportunity through the nature of the investigations to ask the student to observe some object or phenomenon.

Also one of the teacher's overall intents - that "students should observe and measure some phenomenon" probably reflects on the use of this behaviour as a general behaviour pattern in this setting.

However, it was not observed in lesson 3 because he did not have much time to observe the work of all the groups as was his behaviour in the other lessons occurring in this setting. He had to neglect most of the groups during lesson 3 mainly because he was busy laying out a lab test for his grade 9 class on the student working benches. These grade 9 students were expected to come to

the lab to take the test immediately after lesson 3 i.e. during the fifth period of the day. Also, there was not much time left for this setting (12 minutes) and the teacher wanted to use the available time to set up the test.

The behaviour was also not used in lessons probably because this lesson, by the very nature of the directions given for the investigation, did not involve much observation work. The only observation to be done was that of observing the millimeter scale of a ruler under the microscope. However, even though the teacher did not ask the students to observe some object or phenomenon he did ask them to describe what they saw under the microscope by asking questions like: "How many lines do you see under the low power objective lens?" "What about the medium power objective"? This behaviour required the students to observe the object under the microscope.

2. Teacher gives direct answer to students' questions about the investigation procedure (J4).

This is in line with the observation made in discussing the developing text material setting that it was the teacher's normal behaviour of giving direct answers to students' questions although only one question was asked by the students in that setting. In the laboratory setting, the students asked many questions (as was perceived by the teacher) and the teacher was

almost always observed to be quick at giving direct responses to these questions. This is probably consistent with one of his general or overall intents that "students should learn specific course content" But because of this quick reaction to students' questions, the teacher rarely had time to use other alternative forms of responding to their quesitons. However, it was observed that on the few occasions that the teacher had time to reflect on the questions , he almost always gave alternative responses like referring a student question back to the student.

In lesson 9, the teacher did not respond at all to a student's questions because on one occassion he was observed to be busy discussing a point with another student. On another occasion, the teacher was observed to be busy talking to another student who was asking permission to absent herself from the next day's class.

3. Teacher explains why (causality) or how (mechanics) some phenomenon occurred (I4).

Just as the teacher was observed to respond quickly in giving direct answers to students' questions, he was observed to do most of the explanations instead of asking the students to do so. This almost always occurred in response to student questions about the occurrence of some object or structure - "is that round blob the nucleus?"; but at other times the teacher would explain a phenomenon

on his own volition in the process of describing some phenomenon or object probably in order to give further details about an object in his endeavour to achieve his objective - that "students should learn specific course content".

However, in lesson 9, although the teacher spent most of the time in describing the red and white blood cells on the slides to the different working groups, his descriptions did not include any causal relationships or how they occurred partly as he indicated that this content was not required. Also because the teacher realised that there was very little time in this setting (11 minutes) for the students to be able to complete the investigation, he asked the students to "try to do the investigation at least once". This made the students rush through to complete the investigation within the limited time thus leaving them with no time to ask questions requireing explanations.

The teacher was also not observed to offer explanations in lesson 10 probably because of the following reason. During the developing text material setting in lesson 10, the teacher explained the function, occurrence and nature of the different cells in the leaf to the students. Thus, because most of the explanations were provided by the teacher during the developing text material

setting, there was probably no need to repeat it in the laboratory setting. Students were also observed to offer explanations of the occurrence of some object on their own.

4. Students prepared written report of the details and results of the investigation (L3) during this setting.

Although the teacher asked the students - during the prelab setting to write reports of their investigation, students were not observed to write the complete report in the laboratory.

According to the teacher, the written report of any investigation includes not only the observations (including drawings) and results but written answers to the procedure questions and the "actual" lab questions in the lab text. Thus, even though students wrote their observations during the lab setting they did not write their answers to the text questions during most of the lab setting. This was because the teacher expected them to complete the writing of the report, i.e. answering the text questions, as a homework to be done after each investigation and used during the post lab discussions. It was also observed that students rarely had enough time to complete the investigations assigned by the teacher. This explains why the writing of the complete lab report was given to the students as homework and why the students

were not observed to write their reports during most of the laboratory settings.

However, in lesson 9, since the students were not expected to make accurate drawings of the blood cells or indicate the magnification of their drawings, they had enough time to write the full report of the investigation during the setting.

In sum, during the laboratory setting, the teacher encouraged students to carry out the investigations, ask questions and prepare written reports of the investigations. He also moved from one working group to another, asking leading questions, giving direct responses (answers) to students' questions and providing explanations for some phenomenon; however there was no grading of students' lab procedures.

These general behaviours seem to be consistent with such factors as (1) the teacher's tendency to provide "descriptions" and "explanations" of phenomenon (a factor, reminiscent of his dominating behaviour in earlier settings), (2) the teacher's tendency to respond quickly to student questions (also a factor reflecting on his dominating behaviour in earlier settings), (3) the nature of the investigation (topic) which required the observation of objects under the microscope, (4) the teacher's technique of asking students to read the investigation directions during the lab settings (a reflection of the pressure to complete a set of topics), (5) the longer time duration of the lesson, (6) the teacher's perception of the students

as enjoying doing science experiments and participating in class through asking questions and offering unsolicited ideas, (7) the teacher's intent to teach students to observe and measure, and acquire specific course content and science-related manual skills and (8) the prescriptive nature of the lab text which does not allow the students to devise their own procedures.

4.43 Situation Specific Behaviours of the Teacher in the Laboratory Setting.

The situation specific behaviours of the teacher in this setting as identified from behaviour items used in some but not all lessons in this setting in conjunction with other participant observation information were:

1. Teacher asked students to describe some object or phenomenon (I2) in only lessons 2,4,5 and 7.

Although it was the teacher's general behaviour to ask frequently the students to observe an object or phenomenon, it was infrequent on his part to ask them to describe what they saw. The teacher was observed to provide the descriptions almost all the time. This explains why it did not occur very often.

The behaviour was, however, observed in lessons 2,4,5 and 7 not as a regular behaviour of the teacher but as a reflection of some prevailing conditions at the time of the lesson (as in lessons 2 and 5) and the general infrequency of such questions, i.e. out of say, five

descriptions open to both the teacher and the students, the teacher would ask the students to describe just one. During lesson 2 most of the students were called to the counselling office to take an exam thus leaving only 19 students out of the 32 in the class. In addition to this, lesson 2 happened to be the first laboratory lesson during which the students actually learned to manipulate the microscopes. As such the teacher spent much time trying to find out whether students were making the right observations and manipulations by asking them to describe their observations and how they went about it. This is reflected in the high frequency of this behaviour in this lesson.

The investigation in lesson 5 was regarded by the teacher as the basis for the remaining topics to be dealt with for the rest of the term and was the first lesson involving mathematical computations. During the lesson students were to determine the diameter of the field for the three objective lenses from the observation of the millimeter scale on a ruler placed under the microscope and use it to compute the microscope constant. Getting the correct field diameter from the ruler was the key to obtaining the correct microscope constant. As such the teacher spent some time to get students to give accurate descriptions of their observations, resulting in the high frequency of this behaviour in this lesson.

As explained above, the behaviour was observed in lessons 4 and 7 not because it occurred frequently but because it occurred infrequently. That is, in both lessons the teacher as usual did most of the "describing" himself even though he was observed to ask the students on two occassions in both lessons to describe some phenomenon.

2. Teacher asked students to explain why (causality) or how (mechanics) some phenomenon occurred (I3) in only lesson 2.

As already explained, it was the teacher's normal behaviour to provide explanations about the occurrence of some phenomenon. As such, for him to ask a student to provide explanations for the occurrence of some phenomenon would definitely depend on prevailing conditions. This is why it was not observed in most of the lessons in this setting.

However, it was observed to be used in lesson 2. During lesson 2, teacher spent relatively longer times with individual groups of students than in the other lessons because he had only 19 students in the class. Thus he had much time to really get at student's understanding of the phenomenon they were observing under the microscope (the composition of colours in newspaper prints). But even in this situation only one instance of this behaviour was observed which again goes to emphasize the teacher's tendency to offer most of the explanations himself.

3. Teacher responded to student questions about investigation procedure by suggesting a process for answering questions (J1) in lessons 4,5 7 and 8.
4. Teacher answered student questions about investigation procedure with an analogy (I2) in lessons 3 and 7.
5. Teacher referred students questions about investigation procedure back to students (J3) in lessons 2,4,5,7 and 8.
6. Teacher performed part of the investigation for students in response to questions about investigation procedure (J5) in lessons 2,4,5,7, and 8.

As already explained, because of the teacher's tendency to respond quickly to student's questions, he always responded by giving direct answers to their questions except on those few occassions when he paused to reflect on the questions. Thus, the above alternative verbal responses occurred during those occassions when the teacher had time to come up with alternative ways of answering the students' questions. In addition the teacher performed part of the investigation for the students (a non-verbal response) in response to procedural questions in lessons 2,4,5,7 and 8 because in all these lessons (1) teacher did not provide an already prepared slide which the students could refer to in case they encountered

any difficulties resolvable by reference to such a slide as was done in lessons 9 and 10, and (2) the teacher was not kept busy for example arranging a lab test for another group of students as was observed in lesson 3. In lesson 9, the teacher prepared a slide of his blood during the pre-lab setting and in lesson 10 he provided a commercially prepared slide of the cross section of a leaf which the students could refer to in case they were not able to produce a good slide themselves.

In lesson 3, the teacher engaged himself during this setting in setting up a lab test for his grade 9 Earth Science class on the same lab benches that the grade 10 students were working on. He even asked some students to help him because he realised he did not have enough time (12 minutes) during this lab to set up the test. This even caused his general behaviour of moving from "station to station" to correspond mainly to where he placed the test materials (unlabelled rocks). He therefore had no time to perform part of the investigation for the students in response to their questions. Thus occassionally, the teacher asked the students to "describe" and "explain" certain phenomena and responded to their questions in other alternative ways such as suggesting a process for answering questions, by using analogy, by referring students' questions back to them or performing part of the investigation for the students.

These occassional behaviours seem to result from such general behaviours of the teacher as his question-asking behaviour, and his encouragement of the students to carry out the investigations and ask questions. Also such factors as (1) the newness of the techniques or concepts to the students which made it necessary for the teacher to spend much time "explaining" and asking questions, (2) the relatively longer times spent with individual groups and (3) the temporary pause exhibited by the teacher in responding to students' questions.

4.44 Setting Summary

From the above analysis, it can be concluded that the teacher uses both general or recurrent behaviour patterns and situation specific or occassional behaviours in his normal teaching in this setting. This is similar to the conclusion drawn for the preceding two settings. During the laboratory setting, the teacher encouraged students to carry out the investigations, ask questions and prepare written reports of their investigations. The teacher was also observed to move from one working group of students to another, asking questions, giving direct answers to students' questions and providing explanations for some phenomenon but was not observed to grade students on laboratory procedures.

Factors which seemed to contribute to these behaviours include teacher factors such as (1) the teacher's

tendency to "describe" and "explain" some phenomenon and his tendency to respond quickly to student questions (both of which reflect on his dominating behaviour in earlier settings), (2) the teacher's technique of asking students to read the investigation directions during the lab settings (in order to save time), (3) the teacher's perception of the students as enjoying doing science experiments and participating in class through asking questions and offering unsolicited ideas, (4) the teacher's intent to teach students to observe and measure, and acquire specific course content and science-related manual skills, and other factors such as (1) the nature of the investigation (topic) which required the observation of objects under the microscope, (2) the longer time duration of the lessons, and (3) the prescriptive nature of the lab text which does not allow the students to devise their own procedures.

The above general behaviours of the teacher contributed to increased student involvement during this setting. Thus even though the teacher had the tendency to "describe" and "explain" most phenomenon to the students, his general behaviour of asking leading questions enabled the students to "describe" and "explain" certain phenomena. But this particular general behaviour of the teacher - asking leading questions - seemed to be prevalent on those occassions when the teacher spent much time with individual student groups and when the nature of the investigation was such that techniques or concepts

involved were unfamiliar to the students.

On the few occassions when the teacher paused for a while before responding to the students' questions, he did not give direct answers but used other alternative techniques to respond to the questions such as by suggesting a process for answering questions, using analogy, referring student questions back to students and performing part of the investigation for the students.

4.50 POST LABORATORY SETTING

4.51 Introduction

This instructional setting occurred on six different occassions and for the sixth class period observed in the study, it was the only instructional setting observed. It occurred in lessons 3,4,5,6, 9 and 10 of the ten lessons observed in the study. As in the developing text material and pre-lab settings, the post-lab settings were entirely dominated by the teacher; it was essentially based on a one-way "teacher question-student response" interaction. That is, despite the fact that the modified classroom observation instrument did not provide for students' questions, almost all the questions in this setting were asked by the teacher with the students responding only to these questions. Students were observed on only a few occassions to ask questions. One important factor contributing to this was the teacher's close adherence to the lab text. The teacher used the procedure questions

integrated with the lab directions and the questions provided after each investigation in the lab text for the post-laboratory discussions. However, not all the questions in the lab text were asked because the answers to some of the questions involved consulting other reference sources. However, because of the time limitations, the teacher did not ask the students to respond to those questions. All the post lab settings were held on the next day after the corresponding laboratory investigation. This had to be done because of time limitations for each laboratory setting (resulting in the fact that the questions in the lab text were given to the students as homework to be completed for discussion the following day).

Apart from the post lab questions taken from the lab text, the teacher asked other questions one of which appeared in almost all the six lessons in this setting. This question was: "What was the purpose of the (yesterday's) lab?"

According to the teacher the post lab discussions were held in order to help the students to write correct answers in their lab reports since the lab reports served as their notes on the concepts dealt with in each investigation. It was therefore necessary for them to write accurate observations and conclusions in order for it to serve as a useful source of reference for reviewing all the concepts in the investigations later on. Because of

this, the teacher always gave the correct answers to the post-lab questions when the students failed to provide the appropriate correct responses. The students were never asked to re-do the investigations or consult other references because of their inability to answer a question.

4.52. General Behaviour Pattern of the Teacher in this Setting

Following a similar procedure to the one used in the preceding settings, the general behaviour patterns of the teacher in the post-laboratory setting were identified by examining Tables IX and X and Fig. 5 in conjunction with the informal data collected during the study.

i) Consistently Used General Behaviours.

The general behaviour pattern of the teacher as identified from behaviour items used in all the lessons in this setting (Tables IX and X and Fig. 5) was as follows:

Teacher encourages students to state conclusions of their investigations (N5, P5).

This behaviour, considered consistent with teaching the nature of science, was observed to be used in every post laboratory setting. This is reflected in the inferential nature of some of the post-lab questions in the lab text. For example, the following question from the lab text was asked during the post lab discussion in

TABLE IX

Behaviour Items Observed Per Single Occurrences Of The Post Laboratory Setting On A Time Line

Lesson No.	Duration (minutes)	Behaviour Items Observed	Frequency of items
3	24	N5 T aks S to st concl	4
		N8 T aks S to mk pred fr res	2
		P5 S st concl	4
		P8 S mk pred fr dat	1
4	11	N3 T aks S to ident reg in dat	4
		N5 T aks S to st concl	6
		N7 T aks S to rel concl to pst res	1
		N8 T aks S to mk pred fr res	5
		P3 S identify reg in dat	3
		P5 S st concl	5
		P7 S rel concl to pst res	1
		P8 S mk pred fr dat	5
5	20	N5 T aks S to st concl	8
		N6 T aks S to sup concl w evid fr invest	2
		N8 T aks S to mk pred for res	1
		P5 S st concl	7
		P6 S sup concl w evid for invest	2
		P8 S mk pred fr dat	1
6	50	M1 T aks S to gr or othrw org dat	3
		M2 T wks math prob f S	17
		N5 T aks S to st concl	6
		N6 T aks S to sup concl w evid fr invest	3
		N7 T aks S to rel concl to pst res	1
		N8 T aks S to mk pred fr res	11
		N10 T ident sor of er/var in dat	2
		O1 S gr or othrw org dat	3
		P5 S st concl	5
		P6 S sup concl w evide fr invest	3
		P7 S rel concl to pst res	1
		P8 S mk pred fr dat	9

continued...

TABLE IX - (continued)

Lesson No.	Duration (minutes)	Behaviour Item Observed	Frequency of Items
9	7	N5 T aks S to st concl	1
		N7 T aks S to rel concl to pst res	3
		P5 S st concl	1
		P7 S rel concl to pst res	3
10	7	N5 T aks S to st concl	6
		N6 T aks S sup concl w evid fr invest	1
		N7 T aks S to rel concl to pst res	1
		P5 S st concl	6
		P7 S mk pred fr dat	1

TABLE IX - (concluded)

TABLE X

Summary of Observations for the Post Laboratory Setting As Recorded on the Modified Instrument

Number of Times Setting was Observed: 6		
Behaviour Items	No. of Setting Behaviour Occurred	Frequency of Behaviour Items
MO TEACHER: DATA REDUCTION		
M1 Teacher asks students to graph or otherwise organize data	2	4
M2 Teacher works mathematical problems for students	1	17
NO TEACHER: INTERPRETATION OF RESULTS OF INVESTIGATION		
N1 Teacher asks students to compare results among themselves	-	-
N2 Teacher asks for divergent interpretation of results	-	-
N3 Teacher asks students to identify regularities in data	1	4
N4 Teacher asks students to dientify sources of error or variability in the data	-	-
N5 Teacher asks students to state conclusions	6	31
N6 Teacher asks students to support conclusions with evidence from investigation	3	6
N7 Teacher asks students to relate conclusions to past results	3	5
N8 Teacher asks student to make predictions from results	4	19
N9 Teacher asks students to propose further investigations suggested by results	-	-
N10 Teacher identifies sources of error variability in the data	1	2
OO STUDENT: DATA REDUCTION		
O1 Student graph or otherwise organize data	1	3

continued...

TABLE X - (continued)

Behaviour Items	No. of Setting Behaviour Occurred	Frequency of Behaviour Items
O2 Student asks teacher if results are correct	-	-
PO STUDENT: INTERPRETATION OF RESULTS OF INVESTIGATION		
P1 Student compare results with others	-	-
P2 Student discuss divergent interpretations of results	-	-
P3 Student identifies regularities in data	1	3
P4 Student identifies sources of error or variability in data	-	-
P5 Student states conclusions	6	28
P6 Student supports conclusions with evidence from the investigation	2	5
P7 Student relates conclusions to past results	4	6
P8 Student makes predictions form results	4	16
P9 Student proposes investigation suggested by results	-	-
P19 Student asks teacher if conclusions are correct	-	-
P11 Student try to reach concensus on interpretation of results	-	-
P12 Student asks teacher what conclusions should be deduced	-	-

TABLE X - (concluded)

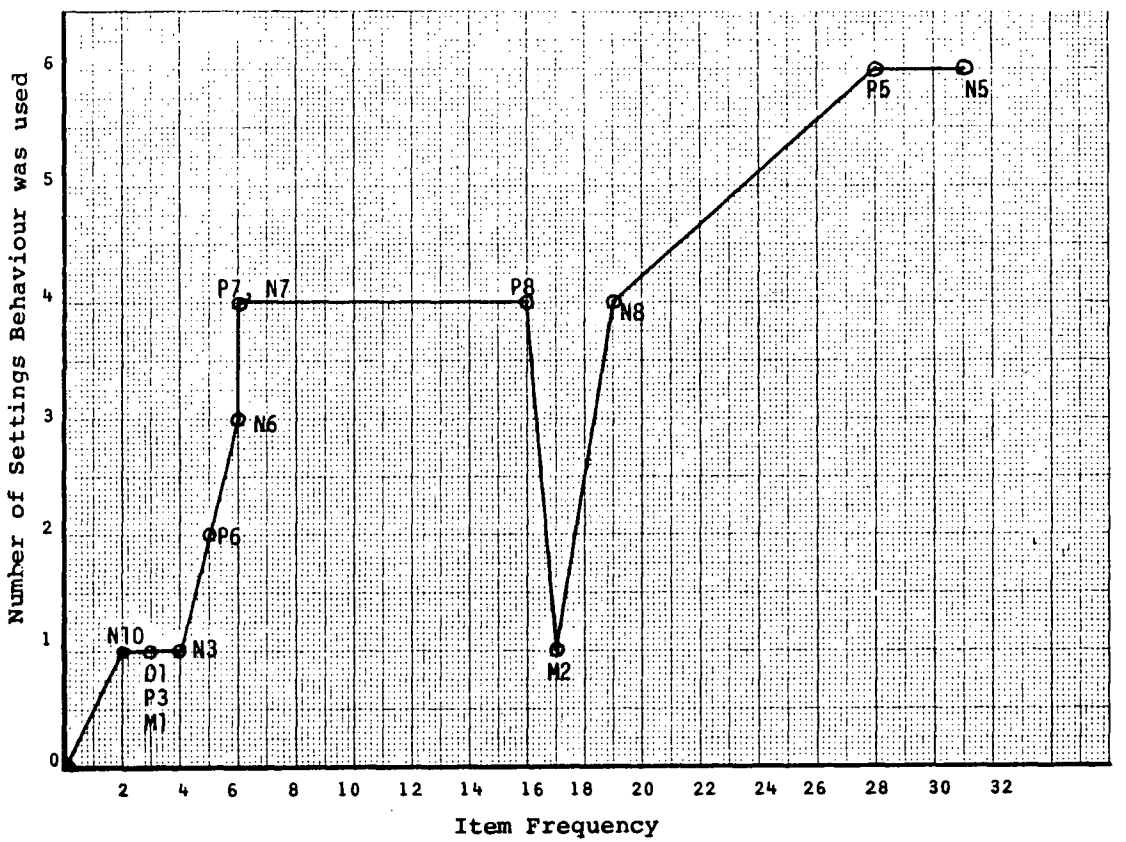

Figure 5. Item Frequency Against Number of Settings Behaviour was used in Post Laboratory Setting

lesson 6:

> "What is the approximate length in millimeters and microns of the micro-organism (shown in the photograph"?).

ii) Unused General Behaviours

The teacher's general behaviour pattern identified from behaviour items not used in this setting were found to be:

1) Teacher encourages students to ask about whether their results or conclusions are correct or what conclusions to deduce from the results (O2,P10,P12).

Students were never observed to ask if their result or conclusions were correct most probably because the teacher was observed to indicate by his immediate verbal comment after each student's answer to his questions that the answer was either right or wrong. He used words like "good", "right", "yes", and "no" which made it unnecessary for the students to ask if their answers were correct.

Students were also not observed to ask for possible conclusions to be deduced from the investigation mainly because the teacher was observed to ask the students to conclude from their investigations as part of his normal or general behaviour. Also since all the questions for the post lab discussions were asked by the teacher, as already explained, the students' most frequent and consistent behaviour during the setting was to respond to the teacher's questions -i.e. this behaviour probably reflects the one

way teacher question - student response strategy adopted in this setting.

2. Teacher encourages students to compare results among themselves or reach concensus on the interpretation of results (N1, P1 and P11).

Because the post lab settings were based on a one way teacher question - student response strategy, the teacher was never observed to encourage students to compare results or try to reach a concensus on their interpretation of their results during this setting because this would have implied encouraging student-student interactions in this setting. However, during the laboratory settings, the teacher was observed to encourage students to observe each other's work in order to compare their results.

3. Teacher encourages the divergent interpretation of results (N2,P2) by the students.

During both the post lab settings and lab settings, the teacher was observed to provide explanations to the divergent results obtained by the students instead of asking the students to provide the explanations. For example, during the post lab discussion of the human blood cells, the teacher explained to the students why the red and white cells were observed to occur mostly around the periphery of the slide. Also during the lab investigation in lesson 8, the teacher explained why a water blob was observed on the slide prepared by a student. This behaviour seems to be part of the teacher's normal tendency to

explain every phenomenon himself (as already explained during the discussion of the laboratory lessons).

Also since there was only "one correct answer" to the questions asked during the post lab, there was probably no need for the teacher to ask for different interpretations or different answers.

4. Teacher encourages the identification of sources of error or variability in the data obtained from the investigations by the students (N4,P4).

Although the teacher had the opportunity in lesson 6, to ask the students to identify the source of variability of the two sets of field diameter and microscope constants obtained during the investigation in lesson 5, he rather chose to identify the source himself by telling the students that they were using two different microscopes. This behaviour is consistent with the teacher's tendency to explain every phenomenon himself.

5. Teacher encourages students to propose further investigation suggested by results of their investigations (N9,P9).

The teacher was never observed to propose or ask the students to propose any further investigations suggested by the results probably because none of the questions in the lab text required such a behaviour. As already explained, with the exception of questions like the one requiring students to restate the purpose of the

investigation under discussion, all the post lab questions were based on the questions in the lab text. But since none of the questions in the lab text required the identification of further investigations, the teacher was not observed to use this behaviour.

iii) Inconsistently Used General Behaviour

The general behaviour of the teacher as identified from items used in some but not all lessons occurring in this setting but regarded from the informal data collected during the observations to be a general behaviour was:

Teacher encourages students to make predictions from results of investigation (N8,P8).

Although the teacher did not encourage students to propose possible investigations suggested by results, he did encourage them to make predictions from the results. This behaviour is considered to be a general behaviour of the teacher because it seemed to generate from the post lab questions in the text material. In lesson 6 where the class discussed the "magnification with the microscope", almost all the questions in the text required the students to use their results on the field diameter and microscope constant to make predictions, e.g. "An object stretches across 1/5 of the high-power field. What is its length? You are told to draw it with a magnification of 200 x. What length will the object be in your drawing?"
This probably explains the high frequency of this behaviour in lesson 6.

The behaviour was, however, not used in lessons 9 and 10 because the questions in the lab text did not require prediction. The questions asked from the text in these settings were:

> "Compare the structures of typical plant and animal cells. How are they similar? How do they differ?"
>
> "Are there any cells which are stained more than one colour? What does this observation tell you about Wright's stain?"

Only these post investigation questions were asked and they do not require the prediction of an outcome.

Apart from the fact that the text questions did not require the use of this behaviour, the teacher was not observed to ask questions which would require the students to predict in lessons 9 and 10. This might be explained by the teacher's indication at the beginning of lesson 9 that he still had a lot of topics to cover in the short time remaining for the rest of the term. It is probably because of this that the post lab setting in lessons 9 and 10 were made relatively short (7 minutes).

In summarising the teacher's general behaviour in the post laboratory setting, it can be stated that the teacher uses this setting to encourage students to make conclusions and predictions from their investigations but did not use it to encourage students to discuss results

among themselves, identify sources of error or variability, propose further investigation or encourage students to ask for confirmation of their results.

Factors contributing to these general behaviours include (1) the predictive and inferential nature of some of the post lab questions in the lab text, (2) the one-way teacher question-student answer interaction (reminiscent of the teacher's dominating behaviour in the earlier settings), and (3) the teacher's tendency to "explain" every phenomenon (also a reflection of his dominating behaviour).

4.53 Situation Specific Behaviours of the Teacher.

The situation speicfic behaviours of the teacher as identified by behaviour items used in some but not all lessons were:

1. Teacher encouraged students to graph or otherwise organize their data (M1,O1) in only lesson 6.

This behaviour was observed to be used in only one of the six lessons in this setting because in all the other lessons neither the teacher nor the text asked for the organization of the data in any special way such as tabulation or graphing. However, in lesson 6 (Table III), the lab text required the students to organize the data in tabular form. During the post lab discussion in lesson 6, the teacher asked the students to tabulate their results

using the outline given in the text.

2. Teacher worked mathematical problems for students (M2) in only lesson 6 during this setting.

Lesson 6, which was the post lab to the lab on "magnification with the microscope", was the first and only lesson in the post lab setting to deal with the mathematical computation of the magnification of objects seen under the microscope and the calculation of the microscope constant to be used or applied in the succeeding lab lessons (lessons 7,8, 9 and 10) to indicate the magnification of their drawings. As such the teacher spent the entire 50 minutes in this lesson trying to get the students to comprehend the calculations involved. He gave them a formula for computing the drawing magnification from the drawing size and the real size of an object and worked examples using the students' data.

In addition, the lab text questions in this lesson, involved computing the magnification from some hypothetical data.

3. Teacher encouraged students to identify regularities in data (N3, P3) in only lesson 4.

From the structure of the lab investigations, this behaviour was found to be more likely to occur in the post lab of the lab investigation of the "characteristics of image" in lesson 4 and the post lab of the topic "living and non-living plant cells". This is because

identifying regularities involve observing more than one object and only these two topics involved the observation of more than one object. In the lab investigation of the "characteristics of the image" in lesson 3, students observed different letters under the microscope and noted what they looked like. Some of the letters like "e" were seen to be inverted while others like "X" retained their configuration. In both lessons 7 and 8, students observed cross-sections of living and non-living plant materials like onion leaves, cork and pith. The non-living cells were found to be devoid of cell contents like nuclei while the living cells contained nuclei. As such in the post lab in lesson 4 students were asked to identify regularities in the data. However, this behaviour was not observed for the post lab lesson of lab lesson 8 because the post lab for this lesson (lab) was not observed due to some technical difficulties which developed with the radio microphone used for the study. Hence it can be stated that the nature of the topic or the structure of the investigation probably rendered the use of this behaviour feasible.

4. Teacher encouraged students to support conclusions with evidence from investigation (N6, P6) in lessons 5, 6 and 10.

As already mentioned, most of the questions used in

the post lab discussions were derived from the text material. But since the lab text questions do not specifically ask for the use of data to support inferences made, this behaviour was therefore not observed in lessons 3,4 and 9. The use of this behaviour in lessons 5,6 and 10, however, seems not to be explained by any of the factors used so far in analysing the different settings. However, it was noted that this behaviour occurred when the students gave "wrong" answers in response to the teacher's questions (requiring them to conclude from the investigation).

5. Teacher encouraged students to relate conclusions to past results (N7, P7) in lessons 4, 6, 9 and 10.

The use of this behaviour in lessons 4, 6, 9 and 10 seems to reflect partly on the lab text questions and on the students' previous knowledge related to the particular investigation. In lessons 9 and 10, the lab text questions related directly to the lab investigations in lessons 7 and 8. In lesson 6, the completion of the table involved the use of the metric system since the diameter of the field was required in millimeters and microns. The teacher therefore asked the students to recall their previous knowledge about the relationship between, say, millimeters and microns in order to convert the numerical conclusions deduced for the field diameter in millimeters into microns. In lesson 4, the teacher

asked the students to relate the image seen under the microscope to the working of a pin-hole camera which the students were already familiar with.

However, no plausible explanation was found for not using this behaviour in lessons 3 and 5.

6. Teacher identified sources of error or variability in data (N10) in lesson 6.

As already explained, it was only in this lesson (lesson 6) that opportunity existed for identifying the source of variability of the two different field diameters obtained for the low power field, the medium power field or the high power field. The teacher was observed to explain that their different results stemmed from the fact that they were using two different microscopes with different constants. This reflects on the teacher's tendency to explain everything himself.

It was also observed that wrong observations or errors made by the student during the laboratory settings were explained by the teacher, thus making it unnecessary for them to be discussed in the post lab settings.

Thus the material (microscopes) used by the students created the variability in the data, and the teacher's tendency to explain things himself caused the use of this behaviour in lesson 6.

In summarizing the situation specific behaviours of the teacher in this setting, it can be stated that occassionally the teacher worked mathematical problems

and identified sources of error or variability in the data and encouraged students to use such behaviours as organizing data, identifying regularities, supporting conclusions and relating conclusions to past results.

Factors which appear to contribute to the use of these behaviours include such factors as (1) the teacher's tendency to explain everything (which is a reflection of his dominating behaviour), (2) structure of the investigation in the lab text which call for tabulation of results or the comparison of different things, (3) the nature of topics which call for mathematical computation and (4) wrong responses given by students to teacher's questions requiring the making of inferences.

4.54 Setting Summary

From the analysis of the behaviour used by the teacher in this setting, it can be inferred that the teacher uses both situation specific behaviours and recurrent or general behaviours in his normal teaching in this setting. The dominant general behaviour used by the teacher in this setting was to encourage students to make conclusions and predictions from the results of their investigations. However, he did not encourage students to discuss results among themselves, identify sources of error or variability, propose further investigations or encourage students to ask for confirmation of their results. These general behaviours appear to

reflect on such factors as (1) the predictive and inferential nature of some of the post lab questions in the lab text, (2) the one-way teacher question - student answer interaction (which reflects on the dominating behaviour of the teacher), and (3) the teacher's tendency to "explain" every phenomenon (also a reflection of his dominating behaviour).

However, on certain occasions, the teacher used certain other behaviours. Thus when the nature of the topic involved manipulating numbers, the teacher was observed to work mathematical problems for the students. Also the teacher's use of such behaviour as the identification of sources of error or variability in the data seems to be consistent with the teacher's tendency to explain every phenomenon which is a reflection of his dominating behaviour.

On occasions when the students give wrong conclusions, the teacher encouraged them to support the conclusions with evidence from the investigation.

Also where the structure of the investigation called for the tabulation of results or the comparison of different objects, the teacher encouraged the students to organize their data in tabular form and to identify regularities in the data.

4.60 QUESTION THREE

The last question in the study - "what classroom settings does the teacher make the most use of for teaching the nature of science during his normal teaching" - required the identification (and subsequent comparison) of the range of behaviour items used out of all the possible behaviour items considered consistent with teaching the nature of science in the different instructional settings and their corresponding average frequencies from Tables II, VI, VIII and X. in conjunction with the list of neutral and consistent items in Appendix F. This procedure offsets the inequalities in the total number of possible behaviour items considered consistent with teaching the nature of science in each of the settings.

In the developing text material Setting, examination of the summary data for the setting, Table II and the items considered consistent with teaching the nature of science in the setting, (Appendix F) shows that out of the 13 behaviour items considered consistent with teaching the nature of science in the developing text material setting, the teacher used 7 (with an average frequency of 15).

Similarly, for the pre-lab setting, examination of the summary data for the setting shows that out of 21 possible behaviours consistent with teaching the nature of science in this setting, the teacher used 12 (with an average frequency of about 3).

In the laboratory setting, out of the 10 possible behaviour items considered consistent with teaching the nature of science in this setting, the teacher used 9 (with an average frequcncy of 23).

In the post laboratory setting, out of the 21 possible behaviours considered consistent with teaching the nature of science in the setting, the teacher used 12 (with an average frequency of 11).

These results can be summarized as follows:

	Developing text material	Pre-lab	Lab	Post-lab
Range (ratio) of items used	7/13	12/21	8/10	12/21
Average frequency of items used	15	3	23	11

Taking both the range (or ratio) of items and their average frequencies into consideration, it can be seen that more items are used in the lab setting and with higher frequency than in the other settings where almost the same range of behaviours are used but with different frequencies. Although the developing text material, pre-lab and post-lab settings have almost the same range of items, the average frequency with which the items are used in the developing text material and post-lab settings are far higher than in the pre-lab setting.

Hence it can be concluded that the teacher teaches the nature of science more in the laboratory setting and

least in the pre-lab setting.

This observation is in agreement with the informal observation data collected in the study where it was found that the teacher allowed the students to dominate the laboratory setting but completely controlled the pre-lab setting and to some extent allowed students to contribute through his questions in the developing text and post-lab settings.

CHAPTER FIVE

LIMITATIONS AND IMPLICATIONS OF THE STUDY

5.00 INTRODUCTION

The primary focus of this study was to describe the behaviour patterns used by a science teacher in his normal teaching that contribute to the teaching of the nature of science and to develop hypotheses about some of the factors contributing to these behaviours.

The specific questions asked in the study were answered by observing one class of the teacher for three weeks using audio and video tape recorders together with participant observation techniques as described in Chapter Three. The tapes were coded by the observer and a trained coder using a modification of Smith's Instrument which contained behaviour items classified as consistent or neutral with respect to the teaching of the nature of science. A pre-study interview and a questionnaire given to the teacher at the beginning of each lesson were used to identify the teacher's overall intent, intent for each lesson and his perception of his students. Other factors such as the teacher's interaction pattern and the structure of the text material were noted through participant observation.

In the preceding chapter, the data obtained from these observations were used as a basis for an analysis of the teacher's behaviour in the different settings and the identification of factors contributing to the teacher's behaviour. From this detailed analysis broad conclusions were drawn.

In the present chapter, the limitations of the study and the implications for further research will be discussed. In addition, the implications for teachers, teacher educactors and program developers will be explored. In looking at the implications for further research and for program developers and teacher educators, some of the findings of the study will be mentioned and related to the literature.

5.10 LIMITATIONS TO THE STUDY

The study explores the factors reflecting the behaviour used by a science teacher that contribute to the teaching of the nature of science during his normal teaching. However, to be able to interpret the findings of the study intelligently, two major problems which limit the generalizability of the study should be recognized. These are (1) problems with the Instrument and (2) problems resulting from a small case study.

In the first case, given the view of the nature of science used in the study, not all possible behaviours are listed in Smith's Instrument. For example the behaviour: Teacher explains the origin, character and role of problems in science, was not included in the developing text

material setting. It may be argued that including all these behaviours may make the task of coding a laborious one. Following from this, it should be recognized that the view of the nature of science used in the study is only one view out of other possible views. As such when these other views are considered, the instrument may be even more inadequate. Also the ground rules for using the instrument do not allow the coding of behaviours in a setting different from the one being observed at any time. Thus if the teacher talks about the historical development of knowledge during the post-lab setting, this behaviour cannot be coded since this item occurs only in the developing text material setting.

In the second case, a case study of one teacher for only three weeks can only be exploratory in nature. A longer period of time with more teachers is needed before more definite conclusions can be reached. In addition, since the teacher was observed to depend heavily on the lab text, the study is limited in some way to the lab text used by the teacher and the students. A lab text with different orientation may produce a different set of teacher behaviours.

Thus with the above limitations in view, the findings of this study are only intended to provide an empirical base for subsequent experimental studies of factors causing teachers to behave in certain ways when teaching the nature of science as part of their normal teaching.

In spite of the above, the study was useful because it identified the incongruity between the teacher's perception of the students - e.g. as contributing unsolicited responses and asking questions in class - and the actual (or observed) behaviour of the students. Also, the analytic technique used allowed the interpretation of the teacher's behaviour in terms of unconscious (unconscious to the teacher) factors operating in the system.

5.20 IMPLICATIONS FOR RESEARCH

The findings of this study, while insufficient for making any strong generalizations due to the limitations described above, do point to certain directions for possible research. The first of these is methodological and is aimed at meeting the limitations described in section 5.20 above. It is proposed that a larger sample of teachers be observed for a much longer period of time for the purpose of making some generalizations. Based on the view of the nature of science implied in Smith's Instrument, all possible behaviours should be included in the instrument to see whether there will be any differences in the patterns exhibited by the teacher. Also different views of the nature of science could be explored (by constructing instruments with these views) to identify the different teacher behaviours which may be observed.

The second direction suggested by this study is substantive in nature and is aimed at exploring and

refining the findings of the study. Recognizing the role of text material in teaching the nature of science, the text materials could be varied in order to determine how the materials change the teacher's behaviour. Also to identify the impact of students on the teacher's behaviour, different groups of students could be used to determine how the different perceptions the teachers have for each group influence the teacher's behaviour; and how these teacher perceptions are consistent with the actual (or observed) behaviours. To identify how relevant the duration of the lesson and the pressure to complete a set number of topics in a limited time are to the teacher's behaviour, the teacher could be asked to teach without any of these restraints to see if the same patterns would be used by the teacher.

One interesting finding of the study was that the teacher's mode of response to student's questions changed whenever he paused for sometime after a student's question. From this it can be hypothesised that an increase in the length of time a teacher remains silent after a student's question will increase the quality of response from the teacher. Although, this is not supported directly by findings reported by Rowe (1974) when studying the effect of "wait-time" on students' and teachers' behaviour, it still has some bearing on her findings. Rowe (1974) noted among other things that an increase in the length

of time a teacher remains silent("wait-time" measured in seconds) increases the net variability in teacher verbal behaviour questions. Although her findings did not report anything on the type of responses given by the teacher after a student's question per se, it has a bearing on the responses given by the teacher.

Another general finding of the study, that the teacher uses general (or recurrent) behaviours in each instructional setting during the three-week observation is supported by the finding of Smith (1969) in his two-week study that a teacher's behaviour "within a classroom setting is relatively consistent in recurring instances of that setting". This is also given further support by the conclusion reached by Urbach (1966) in a two-week study that recurring patterns of verbal instructional techniques do exist for each teacher in the science classroom. The type of recurrent behaviours noted by Urbach (1966) were different from those in this study since he used Flanders' system which contains a different set of categories and is also verbal in nature. Thus the finding in this study that the teacher moved around the groups in all the lessons in the lab setting did not occur in the study by Urbach. However, it is still important to note that in their normal teaching, science teachers use certain recurrent behaviours. The present study in addition to corroborating the findings of the above studies, looked at factors contributing to these recurring behaviour patterns. It also looked at the variation in behaviour (that is, situation specific behaviours) and noted

possible factors contributing to these.

5.30 IMPLICATIONS FOR THE PROGRAM DEVELOPERS, TEACHER EDUCATORS AND TEACHERS.

To identify the implications for program developers, teachers and teacher trainers it might be necessary to look at how some of the findings of this study relate to those of Smith (1969). Smith reported that in the developing text material setting, teachers respond to student questions mainly by giving direct answers and that behaviour items having to do with the philosophy of science were not used by the teachers. These findings are similar to those in this study and probably goes to show the teacher's inadequate perception of how these behaviours related to the philosophy of science are related to and could be taught in the development of text material setting. Program developers aware of this could make it more explicit in their programs that the philosophical basis of science should be transmitted to the students. Inclusion of this in programs would enable teacher educators to emphasize it in their work. Results from this study shows that when the teacher remains silent for some time after a student's question, he almost always use other alternative response behaviours (instead of giving a direct answer). This could be incorporated in a teacher education program to alter teachers' response patterns.

In the pre-laboratory setting, Smith reported that students were never observed to identify and state the

purpose of the investigation problem and relate the investigation to previous work. In this study, it was found that the students were never involved in identifying and stating the investigation problem, in hypothesizing, operationalizing variables and relating the investigation to previous work although the teacher was observed to ask students to state the purpose of the investigation. It was found that the structure of the lab text (including the need to provide certain facts) and the pressure to complete topics do not allow for the use of these behaviours. If the lab text could be organized in such a way that both the syntactical and substantive structures are equally represented, there would not be any need for the teacher to provide the students with extra information (subject matter content). Also if it could be organized in such a way that (1) variables could be identified and hypothesis statements made and (2) students could recognize the relationship between the experiments and previous work, it would make the teacher's task easier and lead to the use of such behaviours. Other findings similar in both studies in the pre-lab are (1) students were never observed to read aloud directions for investigation. (2) Students seldom request clarification of lab directions.

The occurrence of the last behaviour was found to reflect the fact that students only read the lab directions during the laboratory setting. Thus if students could be made to think of the problem for investigation well ahead of

time, illuminating discussions could be generated during the pre-lab.

From the data reported by Smith (1969) it was clear that in the lab setting, the teacher never graded students on lab procedures, always moved from station to station and almost always gave direct answers (as in the developing text material setting) to student questions. The same findings have been reported in this study. In addition, it was found in this study that the text required the teacher to move from station to station and that because the investigation procedures were not devised by the students, there was no need to grade the students on the prescribed directions in the text.

In the post-lab, Smith (1969) reported that "except in the case of asking students to state conclusions, teachers ..... seldom, if ever, ask students the kinds of questions that stimulate communication between students or that lead to critical and speculative analysis of the data". In this study, a similar finding was arrived at - apart from making conclusions and predictions, students were never observed to be encouraged to compare results, discuss divergent interpretations, try to reach consensus on interpretation of results, identify sources of error or variability in data or encourage students to propose further investigations suggested by the results. If it could be made explicit in a program that students should be allowed to

communicate with each other on their results, it may be easier for teachers to encourage this behaviour in the post-lab discussions. Also because teachers may be tied down by the text material, questions in the lab text could be reanalysed to ensure that they encourage critical and speculative analysis of the data.

Although there are certain limitations to the study, it's findings on the pattern of teacher behaviour are well corraborated by the findings of other studies, especially that of Smith. These behaviors, in addition to the factors contributing to them, appear to have potential usefulness for program developers, teachers and teacher educators. However, since this study is exploratory, further research in this direction is needed.

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APPENDIX A

THE MODIFIED
CLASSROOM OBSERVATION INSTRUMENT

DEVELOPING TEXT MATERIAL

A0	Teacher demonstrates the following behaviours relative to the nature of science		
A1	Teacher distinguishes between fact and theory	1.00	(C)
A2	Teacher stresses the tentative nature of current knowledge in science	1.10	(C)
A3	Teacher emphasizes historical development of knowledge in science	1.75	(C)
A4	Teacher explains how information is obtained in science	1.75	(C)
A5	Teacher identified major unsolved problems in science	1.50	(C)
B0	Teacher questions relative to student processes		
B1	Teacher asks students to explain why (causality) some phenomenon occurred	1.10	(C)
B2	Teacher asks students to speculate about the occurrence of future or past phenomena	1.10	(C)
B3	Teacher asks students to define new words used in text	2.00	(N)
C0	Teacher response to student quesitons		
C1	Teacher refers student questions back to student	1.83	(N)
C2	Teacher answers student question with an analogy	1.75	(N)
C3	Teacher responds to student question with, "I don't know but will find the answer for you".	1.75	(N)

C4	Teacher gives direct answer to student question	2.00	(N)
C5	Teacher asks students to find out the answer		(N)
D0	Student process statements		
D1	Student explains why (causality) some phenomenon has occurred	1.10	(C)
D2	Student defines new words used in text	1.83	(N)
D3	Student names objects or structures	2.00	(N)
D4	Student classifies objects or structures	1.83	(N)
D5	Students observe objects or structures	1.25	(C)
D6	Student states hypothesis	1.25	(C)
D7	Students use space/time relationships in explanation or description	1.00	(C)
D8	Student relates newly introduced information to topic of discussion	1.00	(C)
D9	Student identifies problems for possible investigation	1.10	(C)
PRE-LABORATORY			
E0	Teacher: Identification of problem for investigation		
E1	Teacher asks students to state problem to be investigated	1.10	(C)
E2	Teacher asks students to state purpose of the investigation	1.00	(C)
E3	Teacher asks students to relate investigation to previous work	1.00	(C)
E4	Teacher states problem to be investigated	1.83	(N)
E5	Teacher relates investigation to previous work	1.10	(C)
E6	Teacher conducts demonstration relevant to investigation theme	1.50	(C)

E7	Teacher asks students to formulate hypothesis for experiment		(C)
E8	Teacher states hypothesis for investigation		(C)
E9	Teacher asks students to operationalize the variables in the experiment		(C)
F0	Teacher: Directions on Conduct of the Investigation		
F1	Teacher demonstrates use of apparatus or equipment		(C)
F2	Teacher discusses potential difficulties in lab procedure	1.25	(C)
F3	Teacher explains how to make measurements	1.50	(C)
F4	Teacher explains how to work mathematical problems	1.50	(C)
F5	Teacher asks students to prepare a written report of the investigation	1.10	(C)
F6	Teacher makes statement about safety precautions	1.00	(C)
G0	Student: Identification of problem for Investigation		
G1	Student restates investigation theme described by teacher	1.83	(N)
G2	Student states purpose of the investigation	1.10	(C)
G3	Student relates investigation to previous work	1.00	(C)
G4	Student states own problem for investigation	1.25	(C)
G5	Student states hypothesis for investigation		(C)
G6	Students provide operational definitions for the variables in the investigation		(C)

H0 Student: Directions on conduct of investigation

H1	Students proceed with investigation without direction from the teacher	1.50	(C)
H2	Student reads aloud directions for investigation	2.17	(N)
H3	Student requests clarification of lab directions	1.50	(C)

LABORATORY

I0 Teacher: Identification of critical aspects of the investigation

I1	Teacher asks student to observe some object or phenomenon	1.10	(C)
I2	Teacher asks student to describe some object or phenomenon	1.50	(C)
I3	Teacher asks student to explain why (causality) or how (mechanics) some phenomenon occurred	1.50	(C)
I4	Teacher explains why (Causality) or how (mechanics) some phenomenon occurred	1.00	(C)

J0 Teacher: Response to student questions about investigation procedure

J1	Teacher responds to student question about investigation procedure by suggesting a process for answering question	1.75	(N)
J2	Teacher answers student question about investigation procedure with an analogy	1.75	(N)
J3	Teacher refers student questions about investigation procedure back to student	1.25	(C)
J4	Teacher gives direct answer to student question about investigation	1.75	(N)
J5	Teacher performs part of investigation for student in response to question about procedure	2.00	(N)

K0 Teacher: Evaluation

K1	Teacher grades students on lab procedure as they work	1.10	(C)
K2	Teacher asks leading questions to evaluate student work	1.10	(C)
K3	Teacher moves from station to station	1.00	(C)

L0 Student: Identification of critical aspects of the investigation

L1	Students make own observations	1.00	(C)
L2	Student asks teacher for help with investigation procedure	1.90	(N)
L3	Students prepare a written report of the details and results of the investigation	1.10	(C)

POSTLABORATORY DISCUSSION

M0 Teacher: Data reduction

M1	Teacher asks students to graph or otherwise organize data ,	1.00	(C)
M2	Teacher works mathematical problems for students	2.00	(N)

N0 Teacher: Interpretation of results of investigation

N1	Teacher asks students to compare results among themselves	1.00	(C)
N2	Teacher asks for divergent interpretations of results	1.00	(C)
N3	Teacher asks students to identify regularities in data	1.00	(C)
N4	Teacher asks students to identify sources of error or variability in the data	1.00	(C)
N5	Teacher asks students to state conclusions	1.10	(C)

N6	Teacher asks student to support conclusions with evidence from investigation	1.00	(C)
N7	Teacher asks student to relate conclusions to past results	1.00	(C)
N8	Teacher asks student to make predictions from results	1.00	(C)
N9	Teacher asks students to propose further investigation suggested by results	1.10	(C)
N10	Teacher identifies sources of error or variability in data	1.90	(N)
O0	Student: Data reduction		
O1	Students graph or otherwise organize data	1.10	(C)
O2	Student asks if results are correct	2.17	(N)
P0	Student: Interpretation of results of investigation		
P1	Students compare results with others	1.10	(C)
P2	Students discuss divergent interpretations of results	1.10	(C)
P3	Student identifies regularities in data	1.10	(C)
P4	Student identifies sources of error or variability in the data	1.10	(C)
P5	Student states conclusions	1.25	(C)
P6	Student supports conclusions with evidence from the investigation	1.10	(C)
P7	Student relates conclusions to past results (No rating considered consistent by author)		(C)

p8	Student makes prediction from results	1.10	(C)
P9	Student proposes investigation suggested by results	1.10	(C)
P10	Student asks teacher if conclusions are correct	2.17	(N)
P11	Student asks teacher what conclusions should be deduced	2.00	(N)
P12	Students try to reach consensus on interpretation of results	1.25	(C)

APPENDIX B

SPECIAL INSTRUCTIONS FOR RECORDING BEHAVIOURS

1. Fill in the required information (teacher's name, class period, data, etc.) at the top of each page of the observation instrument.

2. The observation of a behaviour will be recorded by a slash placed in the series of boxes at the right of the item. Place only one slash in each box. When all the recording spaces for any one item have been filled, record subsequent behaviours by crossing the existing slashes with another slash. Use a second sheet only when this operation has been completed.

3. Record the occurrence of a behaviour only if it occurs within the situation, e.g. laboratory, post-lab discussion, in which it is listed.

4. Ignore behaviours having to do strictly with classroom management or other forms of administrative activity.

5. Record a particular behaviour each time it is observed except in the following case:

   A. Teacher or student repeats the same statement or question (or only slightly reworded versions thereof) without the occurrence of intervening statements or questions by either teacher or student.

      In the event that exception A occurs, record that particular behaviour only the first time that it is observed in the uninterrupted sequence.

6. Attention is called to the special nature of items K1, K3, L1, and L3 of the Laboratory activity. Each of these four behaviours may consume a considerable amount of time in its demonstration; therefore, the observer will record the occurrence of each of these behaviours only if it is the first time that the behaviour is observed within the laboratory period. Record these items by putting a circle around their identification numbers.

7. Record demonstrations carried out by the teacher during the laboratory period as part of the laboratory period.

8. Record demonstrations which take the whole of a class period under Laboratory setting. If the students do the investigation after teacher demonstration use the pre-lab setting to record the teacher's demonstration.

9. Use counter on tape to signal change of setting.

10. The recording procedure is the same when the class is working individually or in small groups as it is when the class is taught as a large group. The only difference is in the numerical size of the reference group.

11. More than one behaviour may be demonstrated in a teacher or student discourse. When this occurs record each behaviour separately, recording as many identifiable behaviours as possible (in these instances recordings will have to be made quickly. For example, a student statement describing why some phenomenon occurred may also involve a spatial relationship. In this case observer will record the occurrence of both an "explains why" and a "space/time" type of student behaviour

12. The observer (or coder) is cautioned not to expect to record a subsequent student behaviour each time he records a teacher behaviour. Nor should the observer (or coder) expect each student behaviour to be preceded by a relevant teacher behaviour.

13. Do not mark in the totals column.

APPENDIX C

OBJECTIVES FOR SCIENCE TEACHING

The 10 items below cover the possible instructional objectives which a science teacher might choose for a particular lesson. Please indicate which of the objectives below are part of your plan for the coming lesson, and the emphasis you intend to give them.

	HIGH EMPHASIS	LOW EMPHASIS	NOT PRESENT
E.C. STUDENTS SHOULD LAUGH			X
1. Students should learn specific course content.			
2. Student should observe and measure some phenomenon.			
3. Students should identify a problem and/or seek a solution.			
4. Students should interpret data and/or formulate hypotheses.			
5. Students should apply scientific knowledge and methods to other problem areas.			
6. Students should use theoretical models to explain concepts e.g. kinetic theory of gases			
7. Students should acquire specific science-related manual skills e.g. weighing.			
8. Students should develop their interests and attitudes towards science e.g. acceptance of scientific inquiry as a way of thought.			
9. Students should become aware of the technological applications of science			
10. Students should recognize the philosophical limitations and historical background of science.			

APPENDIX D

INTERVIEW SCHEDULE

1) Educational qualification_____

2) Number of years of Science Teaching experience _____

3) Grade level of class_____

4) In terms of other students in the same level you have taught, how would you characterize the students in this class?_____

_____

_____

_____

5) In general, when you teach science how much emphasis would you give to the following objectives? (attached)

6) How would you characterize the students in terms of the following:

(i) Participation in class: Above average____
Average ____
Below average____

(ii) Asking questions in class: Above average _____
Average _____
Below average _____

(iii) Contribute unsolicited ideas in class:
Above average _____
Average _____
Below average _____

(iv) Respond to teacher's questions in class:
Above average _____
Average _____
Below average _____

(v) Do assignments given to them: Always _____
Usually _____
Not at all ____

(vi) Hardworking: Above average _____
Average _____
Below average _____

(vii) Academic status: Above average _____
Average _____
Below average _____

7) Would you say the students enjoy doing science?_____

8) Would you say they enjoy carrying out activities such as experiments in class?_____

9) In general, do you have:

i) about the right amount of assistance in setting up labs?_____

ii) too little assistance?_____

iii) more than enough assistance?_____

10) In general, when you cover topics in the course do you feel you have:

i) about the right amount of time?_____

ii) too little time?_____

iii) more than enough time?_____

APPENDIX E

GUIDING FORM

1. What type of setting is occurring?
2. Is the teacher adhering to the objectives checked in the list?
3. Has part of the lesson been treated in a previous class?
4. Are materials adequate for student's experiments?
5. Are the materials too delicate for student's use?
6. Does the topic lend itself easily to the processes and/or assumptions of science?
7. Size of class.
8. What is the topic for the lesson?
9. Is the teacher given any assistance in preparing for a laboratory class?
10. Is there anything to indicate whether or not students have done assignments given to them?
11. Do students contribute unsolicited ideas?
12. Record other behaviours relevant to nature of science but not present in instrument.
13. Use counter on tape to signal change of setting.
14. Record non-verbal items --D5; E6, F1, H1, J5, K1, K3, L1, L3; M2, O1, P1, P2; in field notes.
15. Circle non-frequency items --K1, K3, L1 and L3 in the laboratory setting when they are observed.
16. If it's a post Lab only go around to see if students have organised data or examine the students' lab report collected by the teacher.
17. Record student responses and questions which may be inaudible on the tape.

APPENDIX F

GRADE LEVEL: DEVELOPING TEXT MATERIAL DURATION

Teacher:_____ Date:_____ Observer:_____ Class Period:_____ School:_____

	TEACHER	Tot
A0	(Nat of S)	
A1	T dst btw fact & thry	
A2	T str tent nat of knldge in S	
A3	T emp hist dev of knldge in S	
A4	T exp hw info is obt in S	
A5	T ident unslvd prob in S	
B0	(T Ques Rel to S Proc)	
B1	T aks S to exp why sm phen occd	
B2	T aks S to spec abt fut or pst phen	
B3	T aks S to def nw wds in txt	
C0	(Resp to S Ques)	
C1	T ref S ques bk to S	
C2	T ans S ques w anlgy	
C3	T resp S ques w "I dn't knw"	
C4	T gvs dir ans to S ques	
C5	T aks S to fd out ans	

	STUDENT	Tot
D0	(S Proc St)	
D1	S exp why sm phen occd	
D2	S def nw wds usd in txt	
D3	S nam obn or str	
D4	S clsfy obj or str	
D5	S obs obj or str	
D6	S st hyp	
D7	S use S/T rel in exp'n or des'n	
D8	S rel nw info to tpc of disc	
D9	S ident prob f poss invest	

II

GRADE LEVEL: PRE-LABORATORY DURATION:

Teacher:_____ Date: _____ Observer:_____ Class Period:_____ School:_____

	TEACHER	Tot
E0	(Ident of Prob f invest)	
E1	T aks S to st prob to be invest	
E2	T aks S to st pur of invest	
E3	T aks S to rel invest pre wk	
E4	T st prob to be invest	
E5	T rel invest to pre wk	
E6	condt dem rel to invest thme	
E7	T aks S to form hyp f expt	
E8	T st hyp f invest	
E9	T aks S to op vav hyp	
F0	(Dir on Condt of Invest)	
F1	T demon use of app or equip	
F2	T disc pot'l diff in lab pro	
F3	T exp hw to mk meas	
F4	T exp hw to wk math prob	
F5	T aks S to prep wrt rep of invest	
F6	T mk st abt saf prec	

	STUDENT	Tot
G0	(Ident of Prob f Invest)	
G1	S rests invest thme des by T	
G2	S st purp of invest	
G3	S rel invest to pre wk	
G4	S st own prob f invest	
G5	S st hyp f invest	
G6	S pr op def f var in sty	
H0	(Dir on Condt of Invest)	
H1	S pro w invest w/o dir fr T	
H2	S rd aloud dir f invest	
H3	S req clar of lab dir	

III

GRADE LEVEL: LABORATORY DURATION:

Teacher:_____ Date:_____Observer:_____Class Period:____ School:_____ Time:_____

	TEACHER																													
I0	(Ident Crit Asp of Invest)																													
I1	T aks S to obs sm obj or phen																													
I2	T aks S to des sm obj or phen																													
I3	T aks S to exp why or hw sm phen occd																													
I4	T exp why or hw sm phen occd																													
J0	(Resp to S Ques Abt Invest Proc)																													
J1	T resp to S ques w pro f ans ques																													
J2	T ans S ques abt invest proc w anlgy																													
J3	T ref ques abt invest proc bk to S																													
J4	T gvs dir ans abt invest proc																													
J5	T per pt of invest f S in res to ques																													
K0	(Eval)																													
K1	T grds S on lab proc																													
K2	T aks ldg ques to eval wk																													
K3	T mvs fr sta-t-sta																													

	STUDENT																													
L0	(Ident Crit Asp of Invest)																													
Li	S mk own obs																													
L2	S aks Tf hlp w invest proc																													
L3	S prep wrt rep of invest																													

IV

GRADE LEVEL: POST-LAB DISCUSSION DURATION:

Teacher:_____ Date:_____ Observer:_____ Class Period:_____ School:_____ Time:_____

	TEACHER	Tot
M0	(Dat Red)	
M1	T aks S to gr or othrw org dat	
M2	T wks math prob f S	
N0	(Interp of Res of Invest)	
N1	T aks S to comp res amg selv	
N2	T aks f div interp of res	
N3	T aks S to ident reg in dat	
N4	T aks S ident sor or er/var in dat	
N5	T aks S to st concl	
N6	T aks S sup concl w evid fr invest	
N7	T aks S to rel concl to pst res	
N8	T aks S to mk pred fr res	
N9	T aks S to prop invest sug by res	
N10	T ident sor of er/var in dat	

	STUDENT	Tot
O0	(Dat Red)	
O1	S gr or othrw org dat	
O2	S aks T if res are cor	
P0	(Interp of Res of Invest)	
P1	S comp res amg selv	
P2	S disc div interp of res	
P3	S ident reg in dat	
P4	S ident sor of er/var in dat	
P5	S st concl	
P6	S sup concl w evid fr invest	
P7	S rel concl to pst res	
P8	S mk pred fro dat	
P9	S prop invest sug by res	
P10	S aks if concl are cor	
P11	S try rech cons on interp res	
P12	S aks T Wh Concl sh be ded	