TEACHER ATTITUDE TOWARD INQUIRY AND TEACHING PRACTICES : A STUDY OF JUNIOR SECONDARY SCIENCE TEACHERS IN TWO SCHOOL DISTRICTS IN BRITISH COLUMBIA

by

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ABSTRACT

Science teaching by inquiry was given much attention by educators and curriculum planners in the 60's and early 70's and is still emphasized in science curricula today. The purpose of this study was to determine the attitudes of junior secondary science teachers toward inquiry and whether such attitudes were related to teaching practices. Specifically, the study set out to determine the attitude towards inquiry of a sample of junior secondary science teachers and to identify the relationships between such attitudes and observed classroom practices, teachers' perception of classroom practices, and students' perception of classroom practices. The study also identified the relationships between teachers' perception of teaching practices and observed classroom practices and students' perception of teaching practices.

The sample consisted of twenty-two junior secondary science teachers from two school districts in the lower mainland of British Columbia and 1,341 students.

Data for the study were obtained through sixty-five audio-taped lessons of the randomly selected teachers (three from each teacher), a teacher questionnaire and a student questionnaire. Teachers were asked questions to determine their attitudes toward inquiry strategies and questions related to their own teaching behaviors, and students were asked to respond to questions about their teachers' classroom practices. The audio-taped lessons were coded using the Science Teaching Observation Schedule (STOS) which provided a quantitative and qualitative record of the classroom behaviors of teachers. Pearson product-moment correlation coefficients were computed for the correlations mentioned.

The results indicated that no relationships exist between teachers' attitudes toward inquiry and their actual teaching practices and their students' perception of their classroom practices; a positive relationship exists between teachers' attitudes toward inquiry and their perception of their teaching practices; no relationship exists between the teachers' perception of their teaching behaviors and their observed teaching practices; and a slight relationship exists between teachers' perception of their teaching practices and their students' perception of their teachers' teaching behaviors.

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CHAPTER I

INTRODUCTION TO THE STUDY

Context of the Problem

The teaching of science as inquiry was given much attention by educators and curriculum planners in the 60's and early 70's (Glass, 1967; Hurd, 1969; Karplus and Thier, 1969; Kuslan and Stone, 1972; Schwab and Brandwein, 1966; and Sund and Trowbridge, 1973). In fact, all the innovative science programs for the elementary and secondary schools funded by the National Science Foundation of the United States in the 60's and are in use today have an inquiry orientation. The Nuffield Foundation projects of Great Britain and other national science curriculum projects of many other countries are of similar orientation. In this respect, the trend in science education has been shifting from the ingestion of information to the acquisition of processes, concepts, attitudes and creativity.

Many new methods of teaching science with emphasis on the inquiry approach have been introduced especially at the secondary level. Lazarowitz and Lee (1976) recommended that the effective implementation of the secondary science curricula developed within the past twenty years required the classroom teachers to use inquiry strategies. These techniques asked the teachers to create learning environments with instructional activities in which students become active rather than passive learners. Textbooks, teachers' guides and laboratory materials were developed and published to meet the need for this type of approach to teaching. New programs were conducted to train teachers in inquiry approaches through in-service. Such techniques and approaches also become part of most pre-service teacher training programs.

Lazarowitz (1973), in reviewing the teaching activities required by the various secondary science programs, stated that this new approach in teaching demanded a radical change in many secondary science teachers' attitudes toward inquiry teaching. Blankenship (1967), in his study concerning teachers' attitudes and the BSCS (1963) curriculum, found favorable attitudes toward the BSCS programs among secondary science teachers who had as many as three years of teaching experience. Ost (1971), from his studies, was able to conclude that the classroom behaviors of teachers and their attitudes toward the BSCS curricular materials and rationale improved after participating in a BSCS institute program. Black (1962) and Sadler (1967) conducted studies on PSSC (1960) teachers and reported that favorable attitudes toward the PSSC curriculum correlated with the teachers' personality traits and intellectual efficiency. Studies by Barnes (1966) and Kochendorfer (1966) showed that teachers who had used BSCS materials for several years had a high acceptance of the BSCS objectives and used laboratory and classroom activities which conformed to the activities recommended by BSCS. The results of Orgren's survey (1977) demonstrated that teachers who adopted the RRESS (1970) curriculum under mandate changed their teaching behaviors in the direction advocated by the curriculum.

On the contrary, Winkeljohn (1972) found that in spite of the the teachers being trained in inquiry-oriented laboratory activities, they still employed content-oriented lectures rather than inquiry-oriented students' activities. Similarly, Wideen (1971) concluded from his study that though the new science programs improved the teachers' understanding of science processes, they had no effect on changing the teachers' belief system or their classroom verbal interactions. Also, Behnke (1961) suggested that although teachers may accept the philosophy of science as inquiry and use the curriculum materials, over fifty percent of the teachers in his study indicated that scientific knowledge does not change.

Lazarowitz, in another study (1976), cautioned that neither the use of new programs nor the length of time they were used would assure proper interpretation of the inquiry approach advocated by the programs. Barnes (1966) and Gallagher (1967) too warned that the mere use of the inquiry program materials did not assure a positive change in the teachers' philosophy toward inquiry teaching or the use of inquiry strategies. To this effect, Hurd (1969) wrote that:

> after a decade of curriculum reform and 'up-grading' of teachers it appears at this time that perhaps as many as two-thirds of the teachers using the textbooks of the new curricula are not teaching the course in the mode envisaged by the authors,

and he continued:

> It is less clear how teaching for concepts differs from teaching for factual information. These new programs demand infinitely skilled teachers using methods of instruction that are supportive of the new goals. And there is little doubt that conventional methods of teaching will not attain these ends. The educational problem is not one of 'methods' or 'no methods' but methods suitable to new goals of instruction, methods that call for teachers to understand the rationale underlying the new courses as well as to know compatible instructional procedures (p. 117).

Koran (1969), like Hurd, had pessimistic pictures of the science teaching situations in schools when he pointed out that until then "the inquiring style of teaching meant to accompany these new materials is little used or poorly understood" by teachers.

Most of the studies that had been conducted during the past two decades compared the effectiveness of different inquiry methods of teaching and traditional methods of teaching on learning, retention and transfer of learning (Anthony, 1973; Cheong, 1971; Dumbleton, 1973; Grimes, 1973; and Murphy, 1978). A few studies had used students only to report on classroom behaviors of teachers, and less few reported the attitudes and actions of individual science teachers especially those not involved in a curriculum dissemination project.

The teacher in any classroom is responsible for the presentation of the science program to the students. High school science teachers, teaching the same topics and using the same text varied very considerably in their teaching methods and activities which resulted from the teachers' interpretation of the curriculum (Gallagher, 1967). Thus, if the new science programs were to be properly implemented, teachers would have to believe in inquiry and stress inquiry behaviors that were consonant with the goals and methods of the programs.

Statement of the Problem

Great emphasis had been placed on inquiry in the teaching of science in the secondary schools for quite sometime. Textbooks for students, guides for teachers and laboratory materials all reflected this inquiry approach. It is appropriate to ask whether or not science teachers believe in the inquiry approach and whether such beliefs are reflected in their classroom practices.

The purpose of this study was to determine what the attitudes of teachers toward inquiry were and whether such attitudes were related to their classroom practices. The specific questions which this study attempted to answer were:

1. To what extent do the teachers' attitudes toward inquiry correlate with their teaching practices as coded from the audio-taped lessons?

2. To what extent do the teachers' attitudes toward inquiry correlate with what they perceived themselves to be doing in the classroom?

3. To what extent do the teachers' attitudes toward inquiry correlate with what the students say their teachers do in the classroom?

4. To what extent do the teachers' perceptions of their teaching practices correlate with what they actually do in the classroom?

5. To what extent do the teachers' perceptions of their teaching practices correlate with what their students say their teachers do in the classroom?

Need for the Study

Much emphasis had been placed on inquiry as a powerful means of instruction and an important competency to be learned by students. Yet in our school system today much of the instructional practices consisted of teacher lecturing and note-taking by the students (Science Assessment Contract Team, 1978). From the study of science teaching in British Columbia, the Science Assessment Contract Team reported that the main activities used by the junior secondary science teachers were "listening to lectures, doing worksheets, copying notes from blackboard or overhead projector, working on problems at the end of chapter in textbook, memorizing science information and reading from textbooks". However, the above list of activities were far from the inquiry approach that has developed over the past two decades and which is typically recommended. In the present times, during laboratory work, students perform experiments from sets of instructions in their textbooks, interpret and report their observations in their own words. The teachers never assign experiments or science projects or reports as homework.

It would appear then that the British Columbia scene is similar to those studied in the United States and the United Kingdom. Several studies had found little acceptance of the inquiry philosophy by teachers in terms of actual classroom practices (Amos, 1970; Koran, 1969; Parakh, 1967; and Raymond, 1973). Other studies had shown that there were many variations in the implementation of the inquiry strategies and that those variations were dependent upon the manner and degree to which the teacher had translated its theory into his own philosophy (Gallagher, 1967; Golmon, 1972; Montague and Ward, 1968; and Sanford, 1977). Galton and Eggleston (1979) studied the actual process of science teaching in the British classrooms of ninety-four teachers and concluded that many teachers adopt teaching styles which run counter to the philosophy inherent in the Nuffield curricula.

Since the teacher is the 'manager of the learning situation', his attitude toward inquiry and the relationship to his teaching practices will be investigated. This study will identify the degree of acceptance of the inquiry approach to science teaching by junior secondary science teachers and what they actually do in their classroom practices. Information about science teachers' attitudes in terms of acceptance, understanding and mastery of the philosophy of the modern science programs could help science educators understand the needs of science teachers particularly the junior secondary science teachers in British Columbia. In addition, it might then be possible to identify any instructional or psychological barriers to inquiry science teaching if there were any. These informations would be of potential value to science educators and science curriculum planners in particular.

Limitations of the Study

Though the schools in the two school districts in British Columbia were randomly selected, the science teachers who eventually took part in the study were asked to participate. The attrition rate was high as many of the teachers did not like to have their lessons observed and taped.

The study was limited to twenty-two science teachers from the Burnaby and Coquitlam junior secondary schools and the students in the classes that were observed.

Owing to the small sample size of the teachers, broad generalizations about science teaching should not be drawn from the data. It should be made clear however that all the data pointed the same direction. The reader is referred here to the study by Cusack (1979).

Audio tapes were used to record all the lessons after the teachers from the first school were opposed to the idea of being videotaped. Taping of the lessons were not made at random, but rather on the basis of convenience for the teachers and observers.

Although every effort was made to minimize classroom interruptions, the presence of an observer, microphones and cassette tape recorder set up in the classroom might have a disruptive influence on student-teacher behavior. This could threaten the validity of the data obtained and the conclusions derived.

There were bound to be some "errors of classification" when the lessons were coded from the audio-tapes. The authors of the schedule used in the lesson coding recommended that "the schedule has been designed primarily for use by observers present at the lesson as it takes place, but it may also be used to classify teacher-pupil interaction as recorded on videotape or even as transcribed from audio-tape" (Eggleston, Galton and Jones, 1975, p. 18).

Since the lessons were coded from audio-tapes, the actual teaching practices of the teachers were confined to the verbal interaction that took place in the classroom between teacher and students and between students and students. No affective or managerial behaviors were coded.

Finally, it was assumed that the teachers and students answered the questionnaires honestly and accurately as strong emphasis was placed on the confidentiality of their answers. However, this assumption may be most difficult to justify for the case of the student questionnaire.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter is a review of selected literature associated with this study. Following the introduction, the concepts of inquiry will be discussed, then the pros and cons for inquiry teaching and the science teacher's role in the inquiry teaching process will be treated. Finally, research findings on the areas of science teaching practices and the relationships to attitude toward inquiry, teacher perception and student perception will be presented.

Introduction

The science programs which were developed in the United States, Great Britain and Australia in the 60's and 70's had emphasized inquiry as a learning objective in the teaching of science. This same philosophy is stressed in the Junior Secondary School Science Curriculum Guide of British Columbia in the statement: "the teaching of science should be based upon inquiry and observation" (Province of British Columbia Science 10, 1970, p. 4) and that "students should emerge from the Junior Science Programme understanding the ways of scientists, able to read instructions and write reports, with a coherent body of scientific knowledge that they understand and can apply to solve problems that concern them" (Province of British Columbia Science 8, 1973, p. 4). The inquiry approach to teaching which is referred to as the hypothetical mode by Bruner (1963) as opposed to the expository mode, allows greater student participation and encourages discovery learning. The learner is motivated by self direction. He avoids rote learning and develops intellectual skills and behavior necessary in a democratic society. Many science educators no longer consider science as a body of classified facts, but instead as a dynamic process of inquiry.

The ideas that are implied in inquiry, however, are not new. They can be traced back to the writings of John Dewey (Worton, 1964, p. 49) in the 30's to present day writers such as Stenhouse (1975, p. 37). Schwab (1966) in "The Teaching of Science as Enquiry" gave some insight to the understanding of inquiry in science teaching. He stated that

> ... the phrase "the teaching of science as enquiry" is ambiguous. It means first, a process of teaching and learning which is, itself, an enquiry, "teaching as enquiry." It means second, instruction in which science is seen as a process of enquiry, "science as enquiry."

Schwab further pointed out that both are important in the inquiry classroom:

> ... on the one hand, its materials would exhibit science as enquiry. On the other hand, the student would be led to enquire into these materials ... In short, the classroom would engage in an enquiry into enquiry (p. 65).

Concepts of Inquiry

From the number of innovations that have been introduced as new techniques in the teaching of science, one would conclude that the concept of inquiry has a wide range of definitions. Several people have taken a fairly general perspective on inquiry. For example, Young (1968) defined inquiry as "a seeking of information by the asking of questions," as typified by the Socratic Method if the teacher asks all the questions. Inquiry was defined as "a search for truth, knowledge and information" by Demchik and Demchik (1970). Rutherford (1964) distinguished between "inquiry as content", and "using the method of science inquiry to learn science", which he called "inquiry as technique" and he was more specific to state that:

> ... it is scientific inquiry we are concerned with, not inquiry in general. Otherwise, if all that is intended by the inquiry method is that we should encourage a student to be inquisitive, curious, to ask questions, and to try to find answers for himself, then we are advocating no more than what good teachers have long believed in and practised (pp. 80-81).

Suchman (1964) in telling about the Illinois Project in Inquiry Training described inquiry as "the act of creating individual knowledge by gathering and processing information."

Many writers had used terms such as "divergent thinking", "creativity", "discovery", "scientific method", "the inductive method", "the student-centered method" and "problem solving" to mean inquiry. Steiner (1970), for instance, suggested that "inquiry as it pertains to science appears to be similar to terms used much earlier, such as 'discovery', 'problem-solving', and 'scientific method'." Anastasiou (1971) advocated the new science teaching approach as inquiry and discovery, defined inquiry as the "special manner in which problems are approached" and discovery as the "hopeful result of that approach to learning." The multiple definitions given to inquiry had given rise to uncertainty as regards to what it means in terms of what goes on in the classroom. This led Hurd (1969) to suggest that:

> A number of new developments have educational labels that are not easily understood, such as, process, inquiry, disciplined centered, discovery and creative. The fact these terms are used suggests the new is not like the old, but how it differs is not so clear. The new labels serve more as slogans than as educational practice, and one is hard put to distinguish class performances taught under one label or another (p. 126).

That inquiry teaching is synonymous with inductive teaching and problem-solving has been supported by Young (1969) when he wrote:

> It is actually a broad term which describes a general method for teaching students the skills of critical thinking, hypothesizing and problem-solving (p. 36).

Voss and Brown (1968) defined inquiry as "an investigation and search for information or knowledge by the asking of pertinent, relevant questions." Novak (1964) talked of inquiry as "the total configuration of behaviors involved in the struggle of human beings for reasonable explanations of phenomena about which they are curious." Rachelson (1977) contended that scientific inquiry is a two-component problem-solving process, namely, hypothesis generating and hypothesis testing of which the latter has been over-emphasized to the exclusion of the former in classroom instruction. He maintained that these two components are dependent on each other. Humphreys (1978) defined inquiry as "the scientist's method of problem solving." The McREL-BSCS Committee on Inquiry Objectives (1969) supported the idea that the inquiry process is a problem-solving process too, so did Gagne (1963) who stated that inquiry is "characterized by a problem-solving approach, in which each newly encountered phenomenon becomes a challenge for thinking."

Unlike Gagne, who was more interested with the end-product of inquiry learning, Bruner (1968) emphasized the process or heuristics of inquiry. In reference to the acquisition of manipulative skills, he stated that "the more one has practice, the more likely one is to generalize what one has learned into a style of problem-solving or inquiry that serves for any kind of task encountered."

Suchman (1968) described inquiry as a pupil-initiated process when he stated:

> ... the more active and autonomous the learner becomes in a learning process and the more he takes responsibility for decisions regarding the collection and interpretation of information, the more meaningful the learning becomes and the more motivated the learner (p. 56).

Fish and Goldmark (1966) talked about inquiry as an approach whereby the students determine the method to use in their inquiry. They then face the result of their decisions and can then analyze the methods which produce these results. Beyer (1971) defined inquiry teaching as "one that has students identify a problem for solution, propose possible solutions, test these possible solutions against the evidence, draw conclusions warranted by the testing and then, later perhaps, apply these conclusions to new data and generalize." Tannenbaum (1969) listed the precedures followed during a scientific inquiry, namely, observing, comparing, classifying, quantifying, measuring, experimenting, inferring and predicting, as scientific processes. Schwab (1963), one of the major proponents of inquiry teaching, stated the following about inquiry:

> To teach science as enquiry means, first, to show students how knowledge arises from the interpretation of data. It means, second, to show students that the interpretation of data – indeed, even the search for data – proceeds on the basis of concepts and assumptions that change as our knowledge grows. It means, third, to show students that because these principles and concepts change, knowledge changes too. It means, fourth, to show students that, though knowledge changes, it changes for good reason – because we know better and know more than we knew before (p. 46).

Cheong (1971), Ivany (1975), Lucas (1971) and Steiner (1970) felt that clarification of these terms is important; and particularly in curriculum evaluation of inquiry teaching, Cheong commented that:

> ...' broad statements of definition of inquiry have limited practical utility for pedagogy and research: in fact indiscriminating use of terms like "discovery", "scientific method" and "problem solving" to denote inquiry without elaboration could generate difficulties in curriculum efforts particularly in evaluating attainments of inquiry teaching (p. 26).

Lucas pointed out the confusion to teachers when such terms were not properly defined by stating that:

> ...' different terms (were) coined to describe essentially similar teaching techniques. But the effect on the classroom teacher trying to decide from the literature which, if any, of these new techniques to use is unfortunate: he is met by an apparently conflicting set of claims, and it is all too easy for him to be lost in a semantic fog (p. 194).

Ivany, in distinguishing between the terms discovery and inquiry, suggested that the Suchman Inquiry-training Program would be more correctly called the guided-discovery instead of the inquiry-training program as there is "a deliberate attempt to structure experiences for children so that through exploration they will be led to find out for themselves some of the basic ideas of science" (p. 136).

Shulman and Tamir (1973) observed that there was some ambiguity in the way in which the terms 'discovery' and 'inquiry' were used. They mentioned three ways, namely, (i) the words are used to describe methods of teaching which are often contrasted with methods described as 'traditional', expository', 'didactic', 'teacher-centered', 'dogmatic', or 'deductive', (ii) the terms refer to processes which occur in the minds of students, and (iii) the terms describe process goals and inquiry processes. Theobald (1977) preferred to use such terms as 'discovery', 'inductive', and 'inquiry' to describe teaching strategies. Stenhouse (1968) tried to draw a distinction between discovery- and inquiry-based teaching when he commented that:

> In discovery-based teaching the teacher introduces his pupils into situations so selected or devised that they embody in implicit or hidden form principles or knowledge which he wishes them to learn... Where a curriculum area is a divergent, rather than a convergent field, i.e. where there is no simple correct or incorrect outcome, but rather an emphasis on the individual responses and judgements of the students, the case for an inquiry-based approach is at its strongest (p. 30).

That discovery learning and inquiry training have much in common has been claimed by Tisher, Power and Endean (1972) when they stated that:

> ...both involve problem solving — the generation of hypotheses and the search for new relationships or recurrent regularities in the environment. In both cases students are, to a greater or lesser degree encouraged to make their own observations, to interpret these and to draw conclusions — with minimal help from the teacher (p. 95).

Based on the literature reviewed, several implications for science teaching can be drawn. Inquiry implies the asking of questions to stimulate divergent thinking in the students, guiding students to discover concepts and principles inductively, teaching the students to solve problems scientifically and to be responsible for their own learning. Thus, for the purpose of this study, particularly with regard to the selection of the instruments used, I shall define inquiry teaching as an approach in science education which aims at engaging students in the process of scientific inquiry through an inductive, student-centered, autonomous and problem solving methodology.

Why Teach by the Inquiry Method?

One of the most valuable objective for science instruction is to develop in students an understanding of the means of solving problems, unfortunately, many teachers in our school system today have traditionally emphasized the product of science (body of knowledge). There should be increased use of inquiry techniques by teachers for the purpose of directing and improving intellectual development (Bruner, 1961). Cheong (1971) proposed the use of inquiry teaching for the development of "the cognitive and effective potentials of the individual." Heath (1964), in comparing the cognitive preferences of students after taking PSSC courses (inquiry) with those of a group after taking non-PSSC courses, found that the students who took the PSSC courses had "developed significantly greater cognitive preferences." Similarly, Wasik's (1971) study showed that the new physics (PSSC) materials were more effective in developing higher cognitive process skills than conventional physics courses. Marks (1967) found a similar result in chemistry. Klopfer (1969) believed that the understanding of the scientific inquiry was a more important factor than the comprehension of concepts. He stated that "a major emphasis in education for science literacy must be placed on the processes of science inquiry." Students taught by the inquiry method exhibit better problem solving skills than those taught by the deductive method (Possien, 1964).

Inquiry training is effective in increasing the divergent thinking ability of students but not so in increasing the science subject-matter attainment of the students (Fanning, 1977). However, Jones (1972) found that inquiry training resulted in greater gain in science subject matter as measured by the Cooperative General Science Test. Also, Schlenker (1970) had shown in his study that inquiry-trained students showed significant gains as measured by the Test On Understanding Science. Similarly, Troxel (1968) found that students who took the new chemistry courses, which were inquiry oriented, performed higher on a test of general chemistry achievement, the Test On Understanding Science, and the Watson-Glaser Test of Critical Thinking Ability than did students in the traditional chemistry courses.

On the contrary, Clark (1968) found in his study that teacher-centered class discussions, lectures and demonstrations were superior to inquiry teaching in increasing the students' achievement in science subject matter. Neal (1961), in his study of techniques for developing science inquiry in elementary school children, concluded that the children's interest in science were increased as a result of the direct approach of teaching the methods of science inquiry.

Bruner (1961) proposed four major benefits of learning by discovery (inquiry). Victor summarized them as:

> The first benefit is to develop an increase in intellectual potency — enabling children to learn a variety of problem-solving techniques, to transform information for better use, and to learn how to learn. The second benefit is a shift from extrinsic to intrinsic rewards — when children shift from learning because of teacher and parental rewards to learning because the learning is self-rewarding. The third benefit is the mastery of the techniques of learning by discovery — when given the opportunity to discover and inquire for themselves, they can transfer this technique to any task they may encounter. The fourth benefit is an aid to memory-processing — the more children learn by discovery or inquiry, the greater the probability that the children can recall what they have learned (p. 25).

Apart from Bruner's four advantages, the inquiry approach helps to build the students' self-concepts, increase their expectancy levels, develops their talents and allows time for students to assimilate and accommodate information (Sund and Trowbridge, 1973).

Critics of the inquiry approach to learning and teaching claimed that inquiry is for the top five or ten percent of students, teachers and institutions. This is not necessary so. Being student-centered, inquiry teaching provides students with opportunities to observe and to carry out individual investigation which is even more suitable for the slower students. In addition, inquiry teaching provides students contact with apparatus which is more effective than non-contact on a measure of laboratory skills (Pella and Sherman, 1969). Critics of the inquiry approach also complained that inquiry teaching is time consuming. Schwab (1960) did not agree when he stated that:

> The problem of finding enough time to "cover" what we wish to cover ... is not and, for years, has not been, a problem of finding enough student time. It has been a problem of finding enough classroom time and enough teacher time to "cover", in the conventional way within the conventional framework of inelastic semester hours, on the assumption that all "coverage" is in the classroom. I now suggest that a substantial part of "coverage" be "covered" by the student on his own (p. 192-193).

Victor (1974) admitted that learning by inquiry takes a lot of time and he reiterated that time is not of prime importance in inquiry learning but discovering answers for themselves is of prime importance in aiding children to 'learn how to learn'. DeShields (1975) supported Victor and Schwab when she concluded in her study that the students who used a process-discovery approach do not necessarily learn more content, but they 'learn how to learn' and how to discover knowledge on their own.

The learning-by-discovery method has been subjected to intense critical review. Wittrock (1966) maintained that "the aging but still elusive learning-by-discovery hypothesis has outlived its usefulness." Strike (1975) believed that research on discovery learning had been inconclusive, and commented that "empirical studies, even conducted with unimpeachable rigor, have failed to agree because they have not shared a common interpretation of either dependent or independent variables." Ausubel (1965), the most renowned critic of Suchman, commented that:

> Grand strategies of discovery, like the scientific method, do not seem to be transferable across disciplinary lines — either when acquired within a given discipline or when learned in a more general form apart from specific subject-matter content.

According to Ausubel,

> ... the only kinds of transfer that have been empirically demonstrated in problem-solving situations are the transfer of specific skills, the transfer of general principles, and the transfer of general approach or orientation to a specific class of problems (p. 258).

In another article, Ausubel (1963) argues that "discovery methods are more relevant to children under twelve years old than to older pupils and tertiary students, since the latter can learn by meaningful reception learning." (Ausubel defined "reception learning" as that in which "the entire content of what is to be learned is presented to the learner in final form.") Shulman and Tamir (1973) stated that although "it has repeatedly been noted that no firm evidence in support of the superiority of discovery learning exists", there are studies by people like Schwab and Bruner which advocated that where transferable problem-solving skills and attitudes are concerned, discovery learning is still a fruitful solution.

The Role of the Teacher in Inquiry Teaching

The philosophy of teaching science as a process of inquiry demands of the teacher a complete changeover in teaching strategy from the traditional to the inquiry method, and has not been easy for the teacher. Teaching by the inquiry approach requires the teacher to make use of a wide range of behaviors in the classroom which involve the scientific processes, namely: identifying problems, making observations, asking questions, defining hypotheses, performing experiments, collecting and analyzing data, interpreting results, drawing conclusions, and making inferences (Lazarowitz, Baurfaldi and Huntsberger, 1978). In the inquiry teaching process, the teacher's task is to help the students to identify problems which may be formulated by the teacher or may be given by the students themselves. Unlike the traditional approach, the students in inquiry learning solve the problems themselves. Another task of the teacher is to make available relevant materials which are necessary for the students' investigations.

Question-asking is one of the most crucial aspects of effective teaching, especially in inquiry teaching, because the kind of questions teachers ask is an indication of the quality of teaching that is going on and the levels of thinking that are being stimulated. Schreiber (1967) and Scott (1966) had found that there was a direct relationship between questioning and inquiry in teaching. Many teachers are not aware of the level of inquiry which questions elicit in the student's mind (Ladd and Andersen, 1970). Francis (1971) also argued that open questions are valuable in helping to raise the level of pupil's thought. Inquiry teaching calls for a high degree of skill in asking divergent or open-ended questions. However, Wright and Nuthall (1970) found convergent questions, not divergent questions, to be related to pupil achievement. Ben Strasser, in a presentation at the National Science Teachers' Association Southwest Regional Conference (1965), had the following to say:

> The kinds of questions we use determine the kinds of operations the children will perform. The questions we use outline the kinds of thinking, observing, and other behaving responses of the learners for which we, their teachers, search... Do we ask only questions which demand recall?... Do we ask only those questions which call for our answers,... or do we ask a variety of kinds of questions which stimulate the range of behaviors which we may readily identify as aspects of sciencing in science education? (Fish and Goldmark, 1966, pp. 13-14).

Bruce (1971) stressed that teachers should help children to learn by developing their listening and questioning skills. He also suggested that the teacher's question-asking ability may be affected by his interests, attitude, academic background and personality.

The roles of the teacher in fostering autonomous inquirers as delineated by Suchman are to:

1. stimulate and challenge the students to think,
2. ensure freedom of operation,
3. provide support for inquiry,
4. diagnose difficulties and help the students to overcome them, and

5. identify and use the "teachable moments" when new organizers can be introduced most effectively.

Schwab (1963) in writing about the Biological Sciences Curriculum Study, which has "Science as Inquiry" as one of the nine themes around which laboratory experiences and content are integrated, suggested that:

> The essence of teaching science as inquiry would be to show some of the conclusions of science in the framework of the way they arise and are tested... [The laboratory experiences] are not illustrative but investigatory. They treat problems for which the text does not provide the answers. They create situations in which the student may participate in the inquiry (p. 40).

The degree of the teacher's direction in the classroom is the most important single difference between inquiry models. Silcock (1969) stated that:

> when the extent of teacher direction is slight the emphasis is usually on inquiry as a process and the traditional disciplines receive little attention. Where inquiry is more highly structured, inquiry skills tend to be less of an end in themselves than a step towards attaining knowledge and developing concepts. Teacher directed inquiry is more likely to emphasize the role of the disciplines. It is suggested that inquiry models can be classified by placing them on a continuum from the most highly directed to one in which pupil inquiry receives little or no direction (p. 30).

Azbell (1977) and Traugh (1974) gave teachers some guidelines for the activity-oriented teaching strategy. Students are to be treated as investigators. The teacher should have a good overall plan with which to begin, for example, he should have the questions and selected learning activities for the children to conduct their investigations under the teacher's guidance rather than the teacher telling and testing the students. Teachers should not expect every child to discover every concept, however, every child should experience some success in discovering some of the concepts. The teacher should see that means are provided to students to formulate and test hypotheses, and materials should not be of the close-up type. The teacher should help the students to realize that a problem can have a variety of solutions. Teachers are to be enthusiastic during the investigations and to show surprise and excitement when the children discover the answers to the problems. The teacher must be always flexible.

Both Suchman and Dewey defined the teacher's role as a guide, assistant and resource person rather than the authority who engineered pupil learning experiences. The students are given maximal opportunity for exploration and trial-and-error experiences. Massialas and Cox (1966) favored a system of teaching in which the students receive much more guidance and direction from the teacher. They even recommended that teachers have a much more controlling role. Gagne (1965) believed in carefully sequencing instructional experiences through maximum guidance so that the students can eventually master the principles of problem-solving. Taba (1967) suggested that the role of the teacher in inquiry teaching is to ask questions which "guide the student's search and lift the levels of thought in order to master essential concepts."

Several textbooks on science methodology have recommended inquiry teaching techniques for the teacher. Examples are textbooks by Romey (1968), Schwab (1963), Sund and Trowbridge (1973) and Voss and Brown (1968). Many of these teacher inquiry roles are identified by Steiner (1970, p. 19) as:

1. Lecture very little.
2. Allow and require students to participate in discussions and laboratory investigations.
3. Encourage and require students to search for ideas and details in various books and journals.
4. Have students identify their own problems, design experiments, collect and interpret data.
5. Allow students time to discuss their experiments and ideas among themselves.
6. Provide students just enough information so that they want to investigate a topic or an idea.
7. Encourage students to carry out individual original investigations.
8. Teach concepts rather than emphasizing isolated facts.
9. Readily admit errors or when appropriate say, "I don't know, but let's find out!"
10. During laboratory periods discuss problems related to the experiment with individuals or groups, question hypotheses, recommend modifications, ask pointed questions and praise work well done.

Barnes (1966) and Kochendorfer (1966), from studies of writings on inquiry teaching and materials of the new science curricula, identified sixty elements of teaching and fifty-three elements of teacher practices respectively.

Good inquiry requires stern discipline, extensive background information and superior organization on the part of the teacher. Every model of inquiry teaching can be classified according to the degree of teacher direction. There is not one inquiry strategy model which is the "best". Each model of inquiry teaching has its own merits for particular students under particular circumstances.

Teaching Practices of Teachers

In this section, research findings of teaching practices in the classroom and laboratory and which are relevant to this study are presented.

Whether or not inquiry is an effective model for classroom instruction had been an issue in many research efforts. Wilson and Koran (1976) are of the opinion that many of these efforts were intended to demonstrate only that inquiry *per se* was better than other methods. However, Shulman (1966) and Hermann (1969) found that the evidence provided by the various studies remained generally contradictory and inconclusive. Amos (1970) in his study on teachers' opinions about the importance of the scientific method in biology courses, found that teachers saw a need to include the scientific method in their teaching. Whether the teachers verbalize a definition of science (inquiry) or not, their practices should be connected to their philosophies of teaching and of science (inquiry) (Snyder, 1978).

Most researchers in science teaching had studied the antecedents and consequences of classroom behavior of teachers and students rather than what teachers and students actually say and do in the classroom. Rutherford (1964) commented that there was a large gap between teacher practices and their convictions when we looked at what actually took place in many, if not most, classrooms and by the kinds of tests which teachers used.

There are very few studies on teacher behavior and attitude in science teaching and in particular attitude toward inquiry strategies. However, enormous amount of researches and writings had been conducted and produced with regard to attitude and behavior relationships in social psychology. For example, Wicker (1969) in his review of empirical research on attitude-behavior relationships cited not less than thirty studies. He concluded in his review that these studies suggest that "it is more likely that attitudes will be unrelated or only slightly related to overt behaviors than that attitudes will be closely related to actions." Insko and Schopler (1967) had suggested that there is a possibility that much evidence showing a close relationship between attitudes and overt behaviors has been obtained but never published because investigators and journal editors consider such findings 'unexciting' and 'not worthy of publication'.

Astin (1965) and Pace and Baird (1966) conducted studies using questionnaires that asked students for their perceptions of classroom procedures and behaviors. They found that this perceptual approach has an advantage as it is directly based on the students' classroom experiences. Barnes (1966), Ivany, Mullaney, Huegel, Faust and Strassenbury (1973) and Kochendorfer (1966) in their studies also made use of students to identify actual laboratory and classroom practices using the Biology Laboratory Activity Checklist, the Physics Teaching Opinionaire, and the Biology Classroom Activity Checklist (BCAC) respectively. Later Sanford (1977) and Steiner (1970) also used the BCAC for students to report what the teachers did in high school Biology classes. Parakh (1968), in his study on teacher-pupil interaction in BSCS Yellow Version Biology classes, found that there were differences between what the teachers thought they did or said they did and systematic observed classroom behaviors.

Parakh (1967) and Snider (1966) reported that teachers talked about 75% of the total class time in lecture-recitation-discussion classes and about 50% of the total class time in laboratory periods with very little student inquiry.

Many claims have been made for the use of the laboratory to achieve the objectives of science teaching particularly that of developing inquiry skills (Brandwein, Watson and Blackwood, 1958; Novak, 1963; and Sund and Trowbridge, 1973). Shulman and Tamir (1973) were right in asking whether the laboratory is carrying out the roles of inquiry efficiently. As Shulman and Tamir had reported, very little research had been done with respect to what is actually taking place in the classroom and laboratory through the daily tasks and activities of the teachers and students respectively. If accurate information need to be obtained for classroom happenings, Shulman and Tamir recommended that direct observation and systematic interaction analyses need to be carried out to study the transactions that occur.

Though in recent years, science educators and science curriculum developers have urged that students be actively involved in the inquiry processes, research shows that students are not encouraged to initiate their own inquiry (Winkeljohn, 1972). In science classrooms, the textbook or the teacher defines the problem and the students do not generate questions on their own. In the new science curricula, great importance is attached to the processes of science as an integral part of science learning and as a result, the emphasis is placed upon observation, making inferences from data and formulating hypotheses rather than simply acquiring and remembering information. Studies by researchers such as Gallagher (1970) had shown that there was a high level of description and teacher explanation in science lessons with little attempt to evaluate or theorize about observed data and other sources of evidence.

A study by Perkes (1967) on the teaching behaviors of teachers indicated that although junior high school teachers had access to the modern materials, their instructional styles placed strong emphasis on fact-finding and repeating information and there was hardly any emphasis on the skills of scientific inquiry.

Atkin and Burnett (1969) referred to several studies which attempted to compare teaching by lecture-demonstrations and individual laboratory work and found that there were few differences in achievement. Students who had worked with laboratory materials developed greater skills in laboratory techniques and procedures than those who had not (Horton, 1952). However, Schefler (1965) reported no statistically significant difference in students' gain in knowledge of facts and principles, understanding of science, or attitudes toward science when he compared two methods of teaching a unit of genetics, namely, by an inductive laboratory approach and a traditional lecture-illustrative approach. In the analysis of the laboratory manuals of the PSSC and BSCS courses, Herron (1971) revealed a shocking difference between the expressed intention of these courses and the manner in which students were expected to work in the laboratory. Probably there are many teachers who are using these curricular materials to dispense knowledge and using the laboratory for drilling and for verification.

Summary

The inquiry approach to teaching and learning is characterized by student-centered rather than teacher-centered activities. Through inquiry, which is the goal common to the various science programs, the students are trained to think critically and creatively and eventually to learn on their own. Although numerous researches had been carried out to study the relationships between student achievement and the reaction to the inquiry process, and other techniques of instruction, there is no conclusive evidence that inquiry is superior. Inquiry teaching does not constitute a single method or style of teaching but consists of a number of different methods depending on the amount of teacher guidance given in the classroom. This type of guided inquiry method is more efficient for student learning though free inquiry has its place, too, in the science classroom. The teacher's favorable attitude toward inquiry is very important if he is to play an effective role in the inquiry teaching-learning process.

Studies in the past have shown that a wide gap existed between the teachers' convictions and what the teachers actually do in the classroom. These studies have made use of teachers or students only to report on the teaching behaviors of teachers. In the review of literature, it was found that there is a paucity of research in the study of the actions and attitudes of science teachers particularly the attitudes toward inquiry as well as the relationships between teachers' perception and actual classroom teaching practices and students' perception of teaching practices. Very little research has been done with respect to what actually takes place in the science classrooms through direct observation and systematic interaction analyses.

CHAPTER III

METHOD AND PROCEDURES

The main purpose of this study was to examine the attitudes junior secondary science teachers hold toward inquiry and to determine to what extent their attitudes toward inquiry correlate with their classroom practices. This chapter includes the selection of the sample, the description of the procedures, instruments and questionnaires used in the collection of the data and the data analysis.

The Sample

The sample in this study consisted of junior secondary (Grade 8 through Grade 10) science teachers from two school districts in the lower mainland of British Columbia in which the populations have a similar socioeconomic background.

A list of all the junior secondary schools in the above two districts was obtained and from it, ten schools (five from each district) were randomly selected. The school boards of the two districts were approached by phone for permission to conduct research in their district. This was followed by a letter with an outline of the research proposal (see Appendix A) sent to the appropriate persons.

Once approval was obtained from the school boards (see Appendix B), the principals and the science department heads of the selected schools were contacted and a meeting was arranged for the researchers to meet with the science teachers of each school to explain the purposes and the procedures that were involved in the project. The teachers were told that the project was a 'multi-purpose undertaking' by two Simon Fraser University education faculty members and three graduate students who were collecting data for their particular areas of interest and the teachers were asked to participate. The time to enter the schools for the data collection was agreed upon. Through this initial meeting with the teachers rapport was established between the members of the research team and the participating teachers. From these two school districts, twenty-two teachers from seven schools participated in the study. Eighteen of the teachers were observed between mid-April to early June 1979 and four of the teachers were observed in Novemher 1979. The classes were observed when the teachers were ready to participate.

Procedures for Data Collection

Many studies on teaching practices made use of instruments or checklists which were answered by either the students or the teachers themselves (Barnes, 1966; Kochendorfer, 1966; Linnert, 1976; and Steiner, 1970). For this particular study, the investigator was interested in looking at the actual classroom practices of the teachers as well as what they said and what their students perceived them as to be doing. Medley and Mitzel (1963) warned that the presence of an observer in the classroom sometimes evokes a great deal of uneasiness among the teachers, thus resulting in atypical behavior of the teachers and the students. One reason for such a feeling is that most classroom observations tend to be related to teacher evaluation. However, the teachers were told that they would not be evaluated and that they were to teach as they would normally do, so that the teaching observed was typical of that normally used by the teachers. The teachers did not appear to be threatened. The choice of the lessons was left to the individual participating teachers.

Each of the participating teacher was given a code number and was observed three times in three different classes and in different grades whenever possible. All the lessons were recorded on audio cassette tapes for later analysis. Videotaping was preferred over audio-taping as this medium would provide an opportunity for viewing both verbal and non-verbal cues. However, audio tapes were used to tape the lessons at the request of the teachers. Two microphones were set up diagonally in the classroom before the students entered the class. During the lesson, an observer sat quietly at the back of the classroom recording the non-verbal activities and other information such as the use of overhead projector, demonstration slides, blackboard work, teacher gestures, etcetera, which took place during the lessons and could not be picked up by the audio tapes. This helped to clarify any ambiguities when the lesson tapes were coded at a later date. The lessons which were audio-taped were full block lessons, and lessons which were occupied wholly by tests were not observed. The students of the classes observed were average students except those from three classes (called modified) who were below average students. The lessons observed seemed to be normal ones, and it was presumed that the presence of an observer, microphones and tape recorder did not affect the classroom behaviors significantly.

After having observed and audio-taped the three science lessons of each teacher, a questionnaire on descriptive data, such as teaching experiences and academic background, attitude toward inquiry teaching strategy and the actual teaching practices as perceived by the teacher himself, was given to each of the participating teachers (see Appendix C).

Following the audio-taping of the lessons, the researchers returned to the classes on a separate occasion to administer the student questionnaire (Appendix D). Only those classes which were observed were given the student questionnaire. In some cases, it was not possible to observe three different classes of a particular teacher because he taught only one or two classes of science. All the same, three of his science teaching lessons were audio-taped, but the student questionnaire was administered only once to the same class. Since all the answers from the teachers and students were treated as confidential, no names were recorded on the questionnaires so that individual student, teacher and school were unidentifiable. The schools and teachers were given code numbers for identification by the investigator.

Instruments Used to Gather Data

Data for this study were obtained from the audio taped lessons, classroom observations, the teacher questionnaire and the student questionnaire. The final versions of the teacher and student questionnaires, shown in Appendix C and Appendix D respectively, include the questions of the other members of the research project team. However, items in the questionnaires which are of interest to this particular study are marked by an asterisk (*).

Part A of the teacher questionnaire is essentially the Inquiry Science Teaching Strategy (ISTS) instrument which is the only instrument found that measures the attitude toward inquiry strategies of secondary science teaching. This instrument, which was developed by R. Lazarowitz (1973), is a Likert-type summated rating scale consisting of forty statements used to sample particularly secondary science teachers' attitudes toward inquiry teaching. The ISTS instrument has a five-point scale in which a subject responds "strongly agree", "agree", "undecided", "disagree" or "strongly disagree" to the items. It requires twelve to fifteen minutes to complete and is easily scored. The score on the instrument serves as an indicator of the teacher's attitude toward inquiry. The ISTS items are related to the behavior of the secondary science teachers in the classroom, the activity of the students in the classroom and at laboratory work, the characteristics and methodology employed by secondary science teachers to present their lessons, and the characteristics of science textbooks. Twenty of the forty items are favorable toward inquiry and twenty are negatively stated. The instrument has a Cronbach alpha reliability of 0.80 when computed for 735 secondary science teachers (Lazarowitz, 1973, p. 67). The ISTS instrument was administered to twenty-nine teachers in British Columbia before this actual study took place and a Cronbach alpha reliability of 0.82 was obtained. The ISTS instrument has construct validity which was established by comparing the mean scores of the attitude scale for four known groups of people with known attitude characteristics (Lazarowitz, 1973, pp. 62-63).

Part B of the Teacher Questionnaire gives data regarding the teacher's background training and teaching experience, while Part C deals with classroom instruction. Self-reporting information regarding teaching practices the teacher perceived himself/herself using in class was obtained from Part E of the Teacher Questionnaire. This section consists of forty items similar to the attitude items in Part A, but with the item order reshuffled.

The Student Questionnaire (see Appendix D) is a parallel form of the Teacher Questionnaire. Only questions 1 and 2 are relevant to this particular study. Question 1 is similar to Part C of the Teacher Questionnaire and deals with classroom instruction. Question 2 in the Student Questionnaire consists of 22 items from Part A of the Teacher Questionnaire with minor alterations made to the wording. Data from the students' perception of classroom practices and experiences helped the investigator to compare what the students said and what the teacher said happened in his/her classroom. The Student Questionnaire takes fifteen to twenty minutes to complete.

The numbers for the Teacher Perception items (Part E of the Teacher Questionnaire) and the numbers for the Student Perception items (Question 2 of the Student Questionnaire) which correspond to the numbers of the ISTS instrument items (Part A of the Teacher Questionnaire) are shown in Appendix E.

Analysis of the Data

The Science Teaching Observation Schedule (STOS)

Several systems for the observation of classroom interaction were considered for the coding of the lesson tapes and the Science Teaching Observation Schedule was found to be the most appropriate for this study as it deals with the processes of science which are an integral part of science learned in schools. See Appendix F for the schedule. The STOS which was developed by Eggleston, Galton and Jones (1975), for example, classifies teachers' questions not in terms of their inferred intent but on the basis of the thought processes elicited in the students, thus enabling the observer to record precisely a selection of intellectual transactions that take place between students and teachers and between students and students in science lessons whether the main component is theoretical or laboratory-based work. The schedule has been designed for use by observers present at the lesson as it takes place, or it may also be used to classify teacher-student interaction as transcribed from audio tapes or videotapes (Eggleston et al, 1975, p. 18).

Method of Coding the STOS

The STOS coding sheet in Appendix F shows the twenty-three subcategories grouped into the five main categories. The whole period of observation is divided into time-sampling units of three minutes duration. Whenever a particular behavior which was specified in the STOS had occurred, a tick was placed in that particular subcategory. Only one tick was made in a cell in a time unit no matter how frequent that behavior occurred during that time-sampling unit. Any number of the twenty-three classified behaviors may be ticked in any one time-sampling unit. This gave the frequency count for any particular behavior. At the end of the coding of each lesson tape, the number of ticks in each subcategory was summed up and expressed as a percentage of the total number of ticks in all the subcategories.

Establishment of Coding Consistency

Prior to the coding of the audio tapes, training in the use of the STOS was undertaken with another graduate student. After studying the manual and memorizing the 23 subcategories of the STOS, both the graduate student and the investigator coded five lesson tapes together. The tapes were stopped whenever there was doubt as to which subcategory a particular transaction between teacher and student was to be placed. It was only after the doubt was cleared and the subcategory agreed upon that the coding was continued.

The coding of all the lesson tapes was done by the investigator. Though this eliminated the problem of inter-observer agreement, McGaw, Wardrop and Bunda (1972), in their review of classroom observation schemes, pointed out the effect of observer or coder bias when one observer or coder was being used. Thus, four other randomly selected tapes were coded independently by the same graduate student (G1) and the investigator (I) and the percentage agreement are shown in Table 1. In addition, another tape was randomly selected and a science educator (S) and a second graduate student (G2) coded the tape independently after they had gone through the STOS manual. Both the science educator and the second graduate student were not trained. The various percentage agreement are shown in Table 2.

Table 1

Percentage agreement of coding between G1 and I (trained)

Tape Number	% agreement
1	87.5
2	82.6
3	76.7
4	80.0

Table 2

Percentage agreement of coding between S, G2 and I (untrained)

Coders	% agreement
I and G2	68.7
I and S	73.4
S and G2	60.0

In order to check for the stability of the coding by the investigator, after all the 65 lesson tapes (one of the tapes was not coded because the lesson was a filmshow) were coded, two of the coded tapes were randomly selected and recoded by the investigator and the percentage agreement was found to be 91.3% and 94.4%.

Derivation of the ISTS Subscales

Specifically, this study was concerned with the relationship between the attitude of junior secondary science teachers toward inquiry and the degree to which their teaching practices were directed toward inquiry through measures of observed teaching practices, the teachers' own perception and the students' perception of their teachers' classroom teaching.

The responses of the 51 teachers (29 teachers who responded to the ISTS instrument before the actual study and the 22 teachers in the actual study) were subjected to factor analysis. This was done in order to reduce the ISTS items to a more limited number of subscales. The resulting five distinct factors with their items and reliability are in Appendix G. These five significant factors which formed the attitude subscales were labelled: A - Need for Structure (5 items), B -The Student as Inquirer (5 items), C- Instructional Inflexibility (3 items), D - Laboratory Follow-up (3 items) and E - Process Skill (4 items). Items of the Attitude Subscales B, D and E are favorable toward inquiry and items of Subscales A and C are negative statements toward inquiry. Items which are favorable toward inquiry were scored 5, 4, 3, 2 and 1 and items which are negative statements toward inquiry were scored 1, 2, 3, 4 and 5 for strongly agree, agree, undecided, disagree and strongly disagree. Items which were left blank were coded as means over all subjects for that item. The score for each subscale was obtained by summing the scores of all the items in each subscale. The Teacher Perception Subscales were derived from the Attitude (ISTS) Subscales by grouping the corresponding items in Part E of the Teacher Questionnaire. The item numbers of Part E (Teacher Questionnaire) and the item numbers of Question 2 (Student Questionnaire) which correspond to the Attitude Subscale item numbers are shown in Table 3.

The relationships between the teachers' attitudes toward inquiry and their teaching practices were determined by computing Pearson product-moment correlation for the teachers' attitudes toward inquiry with three measures of their teaching practices. The three measures of teaching practices were from the lesson tapes, from the teachers' perception of their teaching practices, and from the students' reports. Table 4 is a summary of the procedures for the correlational analysis that was carried out.

Table 3

Corresponding subscale item numbers in ISTS (Attitude), Part E of Teacher Questionnaire (Teacher Perception), and Question 2 of Student Questionnaire (Student Perception)

Subscales	Item Nos.		
	ISTS	Part E	Question 2
A Need for Structure	12	22	6
	17	24	9
	24	1	14
	27	19	-
	35	8	19
B The Student as Inquirer	1	13	1
	11	17	-
	13	37	7
	20	33	-
	30	35	-
C Instructional Inflexibility	4	39	3
	5	28	-
	12	22	6
D Laboratory Follow-up	8	4	-
	11	17	-
	19	14	10
E Process Skill	22	29	12
	30	35	-
	34	7	18
	40	23	-

Table 4

Summary of Procedures for the Correlational Analysis

Question Asked	Procedure Used
1. To what extent do the teachers' attitudes toward inquiry correlate with their teaching practices as coded from the lesson tapes?	Correlation between the Attitude Subscales scores and observed practices.
2. To what extent do the teachers' attitudes toward inquiry correlate with what they perceived themselves to be doing in the classroom?	Correlation between the Attitude Subscales scores and the Teacher Perception Subscales scores.
3. To what extent do the teachers' attitudes toward inquiry correlate with what their students say their teachers do in the classroom?	Correlation between the Attitude Subscales scores and the Student Perception items scores.
4. To what extent do the teachers' perception of their teaching practices correlate with what they actually do in the classroom?	Correlation between the Teacher Perception Subscales scores and observed practices.
5. To what extent do the teachers' perception of their teaching practices correlate with what their students say their teachers do in the classroom?	Correlation between the Teacher Perception Subscales scores and the Student Perception items scores.

CHAPTER IV

RESULTS

This chapter reports the results of the study. The responses of the twenty-two teachers to the ISTS (Attitude toward inquiry) instrument will be presented first and then the results of the correlational analysis will be reported in terms of the specific questions asked in Chapter I.

Attitudes of junior secondary science teachers toward inquiry

The responses of the junior secondary science teachers to the ISTS instrument provided an indication of the teachers' attitudes toward specific aspects of inquiry strategies. The overall mean for all items for the twenty-two teachers was 3.56, standard deviation = 0.3516 and variance = 0.1237 (compared to the overall mean of 3.58 for the 735 secondary science teachers in Lazarowitz's (1973) study). It is more relevant and of interest to look at the pattern of responses of the teachers rather than at the total scores. A breakdown of the twenty-two teachers' responses of strongly agree (SA), agree (A), undecided (U), disagree (D) and strongly disagree (SD) to each of the ISTS items is listed in Appendix H.

More than two-thirds of the teachers in the sample responded either to strongly agree or agree to items 1, 3, 8, 10, 11, 12, 13, 14, 17, 19, 20, 22, 23, 26, 29, 30, 34 and

40. All these items, except items 12 and 17, are statements presenting a favorable perspective toward inquiry. Strongest agreement occurred on five items for which the response pattern was 100% for SA or A, thus indicating a favorable attitude toward inquiry. These included:

8. If unexpected results are obtained, they should be included in the analysis of the laboratory work.

14. A secondary science course should have laboratory experiments integrated with the text materials.

20. One of the roles of the classroom teacher is to present learning situations in such a way that students will raise questions.

22. In a science course students should develop skill in interpreting data.

34. In science class students should learn to make careful and relevant observations.

Of the twenty ISTS items which are unfavorable towards inquiry, only items 28 and 37 elicited responses of D or SD from more than two-thirds of the teachers in the sample indicating a favorable attitude toward inquiry. These two items are:

28. A science teacher should prevent his students from trying to critique scientific material before they master it.

37. Experimental results that differ greatly from what is expected should not be considered.

From this point on, the teachers' responses to the items in each of the Attitude subscales will be reported. Table 5 gives the choice distribution of the twenty-two teachers' responses to the Subscale A items. These items

Table 5

Choice distribution of teachers' responses to items in Attitude Subscale A

Items	SA	A	U	D	SD	Blank
12. In an investigation students should know from the beginning the steps they will perform	9	8	5			
17. At the end of an experiment the science teacher should analyze the results to help students understand them	5	11	4	2		
24. Students will perform experiments successfully when the teacher presents an overall explanation of the subject to be investigated.	3	4	8	7		
27. By presenting an acceptable rule to students the teacher avoids the risk of having them arrive at an incorrect one.	1	6	7	7	1	
35. In general, it is not practical for students to test their own hypotheses.	1	7	3	7	3	1

describe the need for teacher direction which diminishes student activity. Such strategy is contrary to inquiry teaching which enhances the formulation of problems, designing of experiments, and interpretation and analysis of data by the students themselves. More than two-thirds of the teachers responded SA or A to items 12 and 17, indicating unfavorable attitude toward inquiry. The responses for the other three items in this subscale were more or less balanced on both sides of the undecided column. Thus, the junior secondary science teachers were in favor of dominating the classroom teaching process.

The items of Subscale B and the distribution of the teachers' responses are in Table 6. More than two-thirds of the teachers in the sample responded strongly agree or agree to all the Subscale B items, indicating a favorable attitude toward inquiry.

Subscale C items deal with instructional inflexibility which is opposed to inquiry teaching. The inquiry-oriented teacher must be flexible. The teachers' responses to the Subscale C items are shown in Table 7. Item 4 does not encourage thinking. Inquiry teaching requires the teacher to be receptive to any answer given by the students, and to guide the students to think critically. Seventeen teachers responded strongly agree or agree to Item 12, thus indicating an unfavorable attitude toward inquiry.

Table 6

Choice distribution of teachers' responses to items in Attitude Subscale B

Items	SA	A	U	D	SD	Blank
1. A science teacher should encourage students to critically analyze their own conclusions.	13	7	1			1
11. Conflicting data can lead to a useful post-laboratory discussion.	9	11	2			
13. It is desirable to present to students science questions to which answers are not necessarily known.	8	9	2	3		
20. One of the roles of the classroom teacher is to present learning situations in such a way that students will raise questions.	10	12				
30. Unexpected results should be considered as part of the laboratory work.	10	11	1			

Table 7

Choice distribution of teachers' responses to items in Attitude Subscale C

Items	SA	A	U	D	SD
4. A science teacher should immediately correct a wrong answer given by a student.		8	2	12	
5. Experimental results which cannot be interpreted show that the experiment is not appropriate for secondary science course.	3	4	6	6	3
12. In an investigation students should know from the beginning the steps they will perform.	9	8	5		

Subscale D items in Table 8 have to do with the open-endedness of experimental work, involving discussions and developing of thinking in the students. All the items in this subscale elicited more than two-thirds of the teachers in the sample to respond strongly agree or agree, indicating a favorable attitude toward inquiry. In inquiry teaching, students should be encouraged to seek information for themselves after and even during the lesson.

All the items of Subscale E, in Table 9, are concerned with the development of process skills. More than two-thirds of the teachers responded strongly agree or agree to these items, indicating a favorable attitude toward inquiry. Science teaching through inquiry should emphasize process skill development.

Teachers' attitude toward inquiry and actual classroom practices

The relationship between teachers' attitude toward inquiry and teacher classroom practices as obtained from the lesson tapes was determined by correlating the scores on each subscales of the ISTS instrument with the subscale scores on the STOS. From the STOS, the types of questions that teachers asked were classified as low inquiry questions and questions which promote inquiry. Subcategories a_1 and a_2 in the STOS (Appendix F) are questions which demand recall of facts and information, and the application of learned facts and principles to solve problems respectively.

Table 8

Choice distribution of teachers' responses to items in Attitude Subscale D

Items	SA	A	U	D	SD
8. If unexpected results are obtained, they should be included in the analysis of the laboratory work.	12	10			
11. Conflicting data can lead to a useful post-laboratory discussion.	9	11	2		
19. Scientific journals and reference books should be available for students to use while performing experiments.	3	15	2	2	

Table 9

Choice distribution of teachers' responses to items in Attitude Subscale E

Items	SA	A	U	D	SD
22. In a science course students should develop skills in interpreting data.	10	12			
30. Unexpected results should be considered as part of the laboratory work.	10	11	1		
34. In science class students should learn to make careful and relevant observations.	13	9			
40. Differences in data can lead to the proposal of alternative procedures in laboratory work.	5	13	3	1	

They are grouped together as low inquiry questions. Such questions have a limited number of responses, thus allowing students little opportunity to think critically. In order to promote inquiry, teachers should ask more questions which require students to hypothesize and speculate (Subcategory a3), and to design their own experiments (a4). There should be more observational questions because observation is vital to inquiry and concept formation (a5), and questions which deal with explanation and understanding of information (a6 and a7). Hence Subcategories a3, a4, a5, a6 and a7 are grouped together as high inquiry questions. Such questions involve the students in thinking critically and creatively.

A major theme in classroom interaction analysis since Flanders' (1965) work on classroom behavior is the amount of teacher talk and student talk. If teaching consists of teacher telling most of the time, then there is little student inquiry in the learning process. From the STOS it is possible to obtain the amount of teacher-dominated transactions (Categories a, b and c) and student-initiated talk or activities (Categories d and e) in the classroom. The frequency of use of the various subcategories is shown in Appendix I.

Pearson product-moment correlation coefficients of the five Attitude Subscale scores and the four STOS Subscale scores are reported in Table 10.

Table 10

Coefficients of Correlation between the Attitude Subscales scores and the STOS Subscales scores

Attitude Subscales	STOS Subscales			
	A	B	C	D
A. Need for Structure	-0.12	-0.05	0.02	-0.03
B. The Student as Inquirer	-0.18	0.09	-0.08	0.06
C. Instructional Inflexibility	-0.10	-0.22	0.02	-0.02
D. Laboratory Follow-up	-0.21	0.01	-0.20	0.19
E. Process skill	-0.16	0.17	-0.35	0.34

The STOS Subscales are:

A - Low inquiry questions (Subcategories a_1+a_2)

B - High inquiry questions (Subcategories a_3 to a_7)

C - Teacher dominated talk (Categories a+b+c)

D - Student initiated transactions (Categories d+e)

None of the correlation coefficients are significant at the .05 level of confidence. This finding indicates that there is no relationship between the teachers' attitude toward inquiry and what they actually do in their teaching practices as defined by the kinds of questions they asked in the classroom and the amount of teacher talk and student talk.

Teachers' attitude toward inquiry and teachers' perception of their teaching practices

The scores on each Attitude subscale of the twenty-two teachers were correlated with the scores on each Teacher Perception subscale and the correlation coefficients are shown in Table 11. From this Table 11, the positive and relatively high correlation coefficients of 0.41, 0.68, 0.72, 0.66 and 0.70 which are significant beyond the .05 level of confidence indicate that there is a relationship between what the teachers believe themselves to be doing and their attitude toward inquiry.

Teacher attitude toward inquiry and student perception of classroom practices

The mean scores of each of the corresponding student items (Question 2 of the Student Questionnaire) for each teacher were correlated with the teacher scores on the Attitude subscales and the correlation coefficients are presented in Table 12.

Student Items 6, 9, 14 and 19 correspond to four of

Table 11

Correlation Coefficients between the Attitude Subscales scores and the Teachers' Perception Subscales scores

Attitude Subscales	Teacher Perception Subscales				
	A	B	C	D	E
A. Need for Structure	0.41*	0.11	0.55**	0.21	0.08
B. The Student as Inquirer	-0.35	0.68**	0.04	0.51**	0.54**
C. Instructional Inflexibility	0.28	0.23	0.72**	0.24	0.24
D. Laboratory Follow-up	-0.02	0.60**	0.26	0.66**	0.73**
E. Process skill	-0.00	0.57**	0.19	0.52**	0.70**

*Significant at the .05 level of confidence

**Significant at the .01 level of confidence

Table 12

Correlation Coefficients between the Attitude Subscales scores and the Student Items 6, 9, 14, 19, 1, 7, 3, 10, 12, 18 of Question 2 in the Student Questionnaire

Attitude Subscales	Student Item Nos.									
	6	9	14	19	1	7	3	10	12	18
A. Need for Structure	-0.25	-0.21	-0.20	0.34	0.30	0.48*	0.10	0.32	0.32	0.29
B. The Student as Inquirer	0.29	-0.34	-0.23	0.28	0.13	0.14	-0.12	0.01	0.26	0.23
C. Instructional Inflexibility	-0.18	-0.14	-0.18	0.11	0.13	0.45*	-0.20	0.54**	0.34	0.22
D. Laboratory Follow-up	0.17	-0.17	-0.17	0.12	0.23	-0.04	-0.17	0.13	0.38*	0.21
E. Process skill	0.22	0.13	0.04	0.12	0.10	-0.21	0.22	-0.17	0.07	0.19

*Significant at the .05 level of confidence

**Significant at the .01 level of confidence the ISTS items of the Attitude Subscale A, Student Items 1 and 7 correspond to two items of the Attitude Subscale B, Student Items 3 and 6 correspond to two items of Subscale C, Student Item 10 corresponds to the Attitude Subscale D, and Student Item 12 and 18 correspond to items 22 and 34 respectively in Subscale E. None of the Student Items correlated significantly beyond the .05 level with their corresponding Attitude subscales suggesting that there is no relationship whatsoever between the teachers' attitude toward inquiry and the students' perception of their teachers' teaching practices. However, on the basis of the results reported in Table 12, four of the correlation coefficients, i.e. 0.48, 0.45, 0.54 and 0.38, are significant beyond the .05 level of confidence. The discussion turns to an account of the three Student Items. The teachers' attitude toward instructional inflexibility correlated positively with the following Student Items:

7. In science class we sometimes discuss questions to which scientists do not yet know the answers.

10. Scientific journals and reference books are available in the laboratory for me to use while I perform my experiment.

Also the teachers' attitude toward post-experimental analysis has a positive correlation with the following Student Item:

12. My science teacher helps me to develop skill in interpreting data.

On further examination of the Student Items, it could be that in a correlation matrix of this size with fifty correlation coefficients, two to three of these significant coefficients could have occurred by chance.

Teachers' perception of teaching practices and the actual observed behaviors

Pearson correlation coefficients were computed for the five Teacher Perception (Part E of the Teacher Questionnaire) Subscales scores and the four STOS Subscales scores. Only two correlation coefficients were significant and are shown in Table 13. There is a significant correlation beyond the .05 level of confidence between the teachers' perception toward instructional inflexibility and the types of questions asked by the teacher, namely, (1) low inquiry questions or questions that demand the recall and application of facts and principles, and (2) questions that promote inquiry. The negative correlation coefficients between the Teacher Perception Subscale C and both subscales for low inquiry and high inquiry questions suggest that teachers who scored high in the Teacher Perception Subscale C scored low in the low inquiry questions and low in the high inquiry questions subscales.

Teachers' perception of classroom practices and students' perception of teaching practices

Scores on the Teacher Perception Subscales and the mean scores of the corresponding Student Items were computed for Pearson correlation coefficients. The coefficients are shown in Table 14. Student Item 12 is the item equivalent

Table 13

Correlation Coefficients between the Teachers' Perception Subscales scores and the STOS Subscales scores

Teachers' Perception Subscales	STOS Subscales			
	A	B	C	D
A. Need for Structure	-0.00	0.05	0.03	-0.03
B. The Student as Inquirer	-0.18	-0.07	-0.21	0.19
C. Instructional Inflexibility	-0.38*	-0.40*	-0.29	0.29
D. Laboratory Follow-up	-0.08	-0.14	-0.03	0.02
E. Process skill	-0.21	0.11	-0.20	0.18

*Significant at .05 level of confidence

Table 14

Correlation Coefficients between the Teachers' Perception Subscales scores and the mean scores of the corresponding Student Items

Teachers' Perception Subscales	Student Item Nos.									
	6	9	14	19	1	7	3	10	12	18
A. Need for Structure	-0.13	-0.08	-0.01	0.25	0.15	-0.07	0.06	0.01	0.09	-0.01
B. The Student as Inquirer	0.15	0.07	-0.24	0.16	0.08	0.25	-0.16	0.13	0.32	0.23
C. Instructional Inflexibility	-0.17	-0.03	-0.08	0.24	0.13	0.24	-0.07	0.59**	0.33	0.11
D. Laboratory Follow-up	0.16	0.18	-0.19	0.00	0.15	0.11	-0.15	0.28	0.32	0.26
E. Process skill	0.11	0.13	-0.06	0.09	0.16	0.12	-0.01	0.11	0.38*	0.22

*Significant at .05 level of confidence

**Significant at .01 level of confidence of the Teacher Perception item 22 which falls in Subscale E. This item gives a significant correlation coefficient of 0.38 with the Teacher Perception Subscale E. Thus there is consistency between what the teachers said and the students reported regarding the teaching of process skills in the classroom.

Finally, the students' mean scores were obtained for each item in Question 1 of the Student Questionnaire, and these mean scores for each teacher were computed with the teachers' scores to Part C items in the Teacher Questionnaire. Pearson correlation coefficients are reported in Table 15. In Table 15, out of the nine correlation coefficients which were underlined, only three are significant beyond the .01 level of confidence. These three coefficients reveal a consistency between the students' perception and the teachers' perception regarding the following:

a. Listening to lectures or watching demonstration (Correlation coefficient of 0.72).

d. Working on laboratory excercises when instructions are provided (Correlation coefficient of 0.54).

h. Engaging in role playing (Correlation coefficient of 0.67).

The first two items are non-inquiry, while the third item is inquiry oriented. Contrary to inquiry teaching, the teachers in this study lectured a great deal. In laboratory work,

Table 15

Correlation Coefficients between the teachers' scores (Part C of Teacher Questionnaire) and the students' mean scores of the Question 1 items (Student Questionnaire)

Student Items	Teacher Items								
	a	b	c	d	e	f	g	h	i
a. Listening to lectures or watching demonstrations	<u>0.72</u>***	-0.41	0.19	-0.38*	0.11	0.39*	0.02	-0.24	-0.02
b. Discussing topics or issues	-0.48*	<u>0.14</u>	-0.21	0.59**	-0.08	-0.19	-0.27	0.08	0.24
c. Working in groups (other than labs)	-0.12	0.34	<u>0.15</u>	0.01	-0.11	0.18	0.13	0.15	-0.09
d. Working on laboratory exercises when instructions are provided	-0.57**	0.27	-0.37*	<u>0.54</u>**	-0.27	-0.53**	-0.17	0.09	0.03
e. Working individually on issues and problems which students organize or initiate	0.20	-0.26	-0.39*	0.18	-<u>0.03</u>	-0.13	-0.09	0.13	0.14
f. Working individually on issues which the teacher organize	0.09	0.13	0.19	-0.39*	-0.10	<u>0.34</u>	-0.18	0.12	-0.07

Table 15 (continued)

Student Items	Teacher Items								
	a	b	c	d	e	f	g	h	i
g. Receiving instructions through audio-visual, printed or other self-learning materials	-0.05	-0.11	-0.42*	0.25	0.02	-0.39*	0.33	0.12	0.06
h. Engaging in role playing	-0.20	0.01	-0.42*	0.07	0.10	-0.37*	0.28	0.67***	0.25
i. Working on laboratory assignments which students design the procedures	0.41*	0.02	0.71***	-0.39*	0.37*	0.50**	-0.09	-0.22	-0.04

*Significant at .05 level of confidence

**Significant at .01 level of confidence

***Significant at .001 level of confidence

students were given instructions to follow. The mean score for student item i (working on laboratory assignments for which students design the procedures) correlated relatively high (0.71) with the teacher score for item c (working in groups other than labs.). In an inquiry-oriented lesson, these two strategies would be used to a great extent.
The mean scores for student item b when correlated with the teacher score for item a, a significant correlation coefficient of -0.48 was obtained. The mean scores for student item a when correlated with the teacher score for item b, a significant correlation coefficient of -0.41 was obtained. This indicates that when a high score is obtained for one item, the other item will obtain a low score or vice versa. In inquiry teaching and learning, students are actively involved, hence lecturing is contrary to inquiry teaching because the students are involved only in absorbing facts and information. However, discussions involve students much more than lectures and they also develop inquiry behaviors in the students. Student item g mean scores when correlated with the teacher item f scores, a significant correlation coefficient of -0.39 was obtained. Giving instructions through audio-visuals, printed or other self-learning materials is an inquiry teaching strategy, whereas working individually on issues and problems which the teacher organized in a non-inquiry strategy. A negative

correlation coefficient was expected.

Summary

The results of this study are summarized as follows:

1. There was no significant relationship between the junior secondary science teachers' attitude toward inquiry and their teaching practices in terms of low and high inquiry questions that they asked, and the amount of teacher-dominated talk and student-initiated talk.
2. There was a significant relationship (positive correlation) between the junior secondary science teachers' attitude toward inquiry and their perception of what they did in the classroom.
3. There is no significant relationship between the junior secondary science teachers' attitude toward inquiry and their students' perception of their teachers' teaching practices.
4. There is no relationship between the junior secondary science teachers' perception of their teaching behaviors and their observed teaching practices.
5. There is very little relationship between the junior secondary science teachers' perception of their teaching practices and their students' perception of their teaching practices.

The discussion of the results is in Chapter V.

CHAPTER V

CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

This study was an investigation of junior secondary science teachers' attitudes toward inquiry and the relationship between their attitudes and their teaching practices. The teaching practices were obtained through three measures, namely, from the classroom observations, from the teachers' perception of what they do in the classroom and from the students' reports of what their teachers do in their teaching practices.

This chapter provides a summary of the junior secondary science teachers' attitudes toward inquiry and a discussion of the findings related to the questions asked in Chapter I. Recommendations for further study are given at the end of the chapter as well.

Conclusions

Junior secondary science teachers have favorable attitudes toward inquiry. This conclusion was based on the results of the examination of the teachers' responses to the items in the ISTS instrument. More than two-thirds of the teachers in the sample agreed to sixteen out of the twenty inquiry items in the ISTS instrument. This conclusion supports Lazarowitz's (1973) findings that secondary science teachers have favorable attitudes toward inquiry strategies. This is not surprising because during the past two decades with the vast amount of literature written on inquiry and inquiry teaching in science, one would expect the teachers to be aware of the inquiry approach which is recommended in the textbooks, teachers' guides, laboratory aids, university courses and the in-service programs. Junior secondary science teachers had difficulty in responding to the non-inquiry items. This was concluded from the inconsistent responses of the teachers to the non-inquiry items in the ISTS instrument. The responses were distributed on either side of the undecided column of the ISTS instrument as well as for the undecided column.

It was also concluded that the teachers' attitude toward inquiry was not related to their actual teaching practices and what their students perceived them to be doing in the classroom. However, the teachers' attitude toward inquiry was highly related to their own perception of their teaching practices.

Finally, it was concluded that the teachers' perception of their classroom behavior was not related to their actual observed practices, but was slightly related to what their students perceived them to be doing in the classroom for activities such as listening to lectures and watching teachers perform demonstrations.

Discussion

The first conclusion was made after careful study of the teachers' responses for all the items in the ISTS instrument. The results show that the junior secondary science teachers believe that the teacher's roles in the science classroom are: to create learning environments in which students can raise questions; to help students develop process skills such as making careful and relevant observations and interpreting data; to rouse the students' curiosity before a lesson; and to present to students problems to which answers are not known yet. They also believe that they should be receptive to any reasonable answer given by the students and that science teaching should encourage students to identify assumptions, to critically analyze their own conclusions and to include unexpected results in the analysis of their work. The responses also indicated that science teachers think that the science course should include more learning materials than what they intend to use, that the textbooks should have laboratory experiments integrated with the text materials, and that reference materials should be made available for the students to use while they are performing their experiments. As opposed to inquiry, many of the science teachers think that their students should know from the beginning the steps that they will employ in an investigation and that they should analyze the results for the students after an experiment. It was observed in all of the laboratory lessons that experimental procedures were given either in the students' textbooks or from overhead projections or in handouts for the students to follow. A number of the teachers also agreed to other non-inquiry statements such as: the science teachers should make clear in advance all the problems which arise in the performance of an experiment, they should formulate the problems to be taught in science as well as the hypotheses when questions are raised, and they should help the students to obtain a solution whenever a scientific problem is introduced.

The finding that there is no relationship between the junior secondary science teachers' attitude toward inquiry and what was actually observed in the classroom tends to support the findings of many studies on attitude-behavior relationships and Rutherford's (1974) statement that there is a large gap between the teachers' practices and their convictions. To my mind, there are psychological and instructional barriers to inquiry teaching which the teachers need to overcome. Many teachers do not know how to teach the inquiry method and therefore they tend to teach in the way that they were taught. Contrary to the inquiry type of teaching, a large proportion of the teacher talk in the classroom consisted of the giving of information and statements of facts to the students. The teachers seem to think that lecturing and reading from textbooks are the fastest ways to get facts to the students and that student

learning is measured by the amount of facts their students can recall in the type of tests given by the teachers. It appears that the long-term goal of teaching the students to learn on their own has been overlooked. In the classroom teaching, it was noted that the junior secondary science teachers asked mainly convergent questions, that is, questions which require the students to recall facts and questions which demand the application of facts and principles to solve problems. There was relatively infrequent use of questions which require the students to formulate or speculate hypotheses as well as to design their own experimental procedures or to formulate conclusions from the obtained data as one would expect in an inquiry lesson.
From Appendix I, which gives the percentage use of the 23 STOS subcategories by the junior secondary science teachers, the amount of teacher talk ranged from 30% to 90% of the class time. This finding is consistent with Parakh (1967) and Snider's (1966) studies, though the mean for the junior secondary science teachers was slightly lower (62%) than the 75% that was reported by them. In the three cases where the amount of student initiated talk and/or activities was greater than the amount of teacher talk, all the three lessons which were audio-taped from Teachers 7, 11 and 16 consisted of practicals or laboratory work. Though there was clearly a much higher level of pupil participation, it should be pointed out that, of the students' behaviors that

were directed to teachers, they were for the confirmation of facts and principles as well as for experimental guidance. However, much of the student-to-student transactions were difficult to discern as it could not be ascertained whether what the students were talking about were related to the lessons or otherwise.

The link between the junior secondary science teachers' attitude toward inquiry and their perception of their teaching practices was expected because of the close relationship between the teachers' attitude toward inquiry and the teachers' perception of their teaching practices. This could well be that the items of the ISTS instrument and the Teacher Perception items are equivalent items. The ISTS instrument and the Teacher Perception questionnaire were taken by the teachers successively, and the teachers' responses to the ISTS items might have an influence on the responses to the Teacher Perception items.

The students' perception of their teachers' teaching practices has no relationship to the teachers' attitude toward inquiry. Most of the studies on teaching practices in the past had made use of students to report on the teachers' behaviors in the classroom because it was felt that the students were the best people to do so as they are with the teachers for the major part of the day. This did not take into account the affective behaviors of the students. The accuracy of the students' report may have to be taken with a grain of salt as it might be affected by their likes or dislikes for their teacher. One other probable reason for the lack of relationship between the teachers' attitude and the students' perception of classroom practices is that the semantic value of the Student Questionnaire items may not be identical to the corresponding ISTS items. Finally, a third possible reason for this lack of relationship lies in taking the mean scores for the Student Questionnaire items from the three classes of each teacher together. It might be interesting to know what the correlation would be when the mean scores of the students' items for the three classes were taken separately.

The finding that there is no relationship between the teachers' perception of their classroom behaviors and the actual observed behaviors, confirms the findings of many previous studies such as those done by Behnke (1961), Koran (1969), Parakh (1968) and Winkeljohn (1972). The fact that the correlation coefficients were negative for both low and high inquiry questions and instructional inflexibility indicated that if the teachers were authoritarian in their classroom teaching, then there would be very little opportunity for the students to talk and discuss, not to mention to answer any questions when asked by the teacher.

It was observed that most of the schools, which were visited, were well-stocked with apparatus and equipment and had facilities suitable for laboratory work. In fact, in all of the schools visited, laboratory preparation rooms were available, and in five out of the seven schools a laboratory assistant was accessible to the science teachers for the preparation of laboratory equipment and materials. Thus, one would expect much more individualized laboratory work among the students, but this was not the case in the lessons that were observed, because in most of the classes, the students were required to carry out the same experiment or activity at the same pace. The teachers did make use of audio-visual aids such as the overhead projector but often it was used to project notes and experimental procedures for the students to copy into their notebooks. It would appear that the junior secondary science teachers did not know the way to teach by inquiry, for example, in the proper use of the overhead projector for inquiry teaching and in the use of proper questioning techniques in order to make the students think. In most cases, when the students asked something of the teacher, he simply told them the answer instead of probing the students for the answer. Many of the teachers were concerned with getting the right answer from the students. In addition, very limited amount of class discussions were noticed. More work certainly need to be done to train and to retrain teachers in the art of inquiry especially in the techniques of questioning in the science classroom.

There appeared to be a slight relationship between what the junior secondary science teachers said they do and what their students reported them to be doing in the classroom. In Table 14, regarding the teaching of process skills in the classroom, there is some consistency between what the teachers said and what the students reported (significant correlation coefficient of 0.38). It could well be that the two significant correlation coefficients in Table 14 could have occurred by chance, too. With reference to Table 15, there is very little discrepancy between what the teachers perceived themselves to be doing and what their students perceived their teachers to be doing with regard to the following instructional strategies:

Item (a) listening to lectures or watching demonstrations;

Item (d) working on laboratory exercises when instructions are provided; and

Item (h) engaging in role playing or other simulation exercises.

Items (a) and (d) are strategies which are opposed to inquiry teaching as the students are not actively involved in the learning process. When the teacher lectures too much, the students would 'tune out' as their attention span is short. It was observed that the laboratory work consisted of students following instructions given by the teachers or from their textbooks as reported by the teachers and students, too.

The laboratory was used mainly for the verification of information that was given by the teacher in the lectures or from diagrams on blackboard, charts or overhead projections. Very rarely were students asked to design experiments, to speculate or formulate hypotheses or to make inferences from data collected. In no way was the laboratory used as a scientist would use it. These findings confirmed the British Columbia Science Assessment (1978) and Cusack's (1979) findings. The teachers and students responded that role playing and simulation exercises were hardly used in their science classroom instruction (significant correlation coefficient of 0.67). This inquiry strategy was not observed in any of the lessons.

Thus, there were wide discrepancies between observed classroom teaching practices and what the teachers believed, and also between observed teaching practices and what the teachers think they did or said they did and what their students perceived their teachers to be doing. Perhaps one reason for the lack of use of inquiry strategies in classroom teaching today may be summarized by this quotation:

> The present political climate is more likely to direct teachers' concern towards core curricula and the most efficient ways of getting facts across to students. Teaching practices ... which utilize enquiry methods are outside the zeitgeist of the "back to basics" trend (Cusack, 1979, p. 100).

Recommendations for Future Research

It was evident from this study that the junior secondary science teachers were aware of several inquiry strategies, however, their teaching practices did not reveal these. An investigation into the barriers to inquiry teaching could certainly help to increase the use of inquiry strategies in science teaching in the secondary schools.

A considerable portion of the interactions between teacher and students at individual or group laboratory work consisted of inaudible conversations. It would be worthwhile to consider a more sensitive way of monitoring these transactions. This would add to the accuracy of the recording of the lessons on audio-tapes for such research in the future.

In this study, the mean scores for all the three classes taught by each teacher were correlated with the teachers' scores. A further investigation could be carried out by correlating the mean scores for each of the three classes and the respective teacher scores and compare the results.

A study into the factors that might be influential in the formation of more favorable attitude toward inquiry might prove to be of some value.

Very little relationship was found between student perception, teacher perception and observed teaching practices. Future studies on teaching practices should not depend too much or entirely on what students or teachers say, but rather on systematic classroom observations.

It was concluded in this study that the teachers' attitude toward inquiry was not related to their actual teaching practices. Owing to the lack of a common definition for inquiry teaching, an alternative hypothesis would be that the teachers might believe that they are teaching by inquiry according to their own definitions. In this case, the gap between attitudes toward inquiry and actual teaching behaviors would not exist according to the terms of this study. Further research might explore how the teachers define their approaches to inquiry teaching and then to see whether discrepancies exist between what they describe and what they actually do.

The Science Teaching Observation Schedule gives a very detailed record of the intellectual transactions between teacher and students and between students and students in the actual classroom situation but were not exhaustively studied. As such, a more comprehensive examination of the pattern of behaviors that are involved in the teaching of secondary school science would be another area for future study.

APPENDIX A

Outline of Research Project Proposal to School Boards

Secondary Science Research Project

Purpose of the Study

The purpose of this study is to determine how science is currently being taught and to determine what factors, situations and constraints influence that teaching. From this, we can then investigate questions such as: Do current strategies reflect those recommended in the literature? Do teachers find themselves constrained to use certain teaching methods because of external pressures?

Those who have studied innovation in education have shown that the process of change is enormously difficult to effect. Therefore, a second area of investigation involves identifying the barriers which teachers encounter when they try to change their method of instruction.

Thus the overall intent is to determine how science is being taught, what factors influence teachers to teach as they do, and what steps are likely to be the most productive in changing the method of instruction.As a means of initiating a line of research into this area, the following specific objectives have been set for the project:

a. To identify the teaching strategies most commonly used by a representative sample of teachers.

b. To determine the extent to which the strategies identified in 'a' are related to various factors including teacher attitude toward science as inquiry.

c. To identify those strategies of change to which teachers are likely to respond.

d. To identify the barriers to improving the quality of instruction as perceived by teachers.

Procedure

In order to achieve these objectives, we propose to obtain data from a random sample of 30 teachers using interviews and a questionnaire, and collecting three audio tapes of each teacher's classroom teaching. The analysis of the audio tapes coupled with the interview data will enable the researchers to identify the teaching strategies most commonly used by the sample of teachers.

The questionnaire and interview will be structured to gather data on a range of factors that will be related to the teaching strategies and the teachers' attitudes towards these strategies and toward strategies of change. A parallel form of the teacher questionnaire will be given to students in those classes which will be audiotaped. This administration is expected to take approximately twenty minutes of class time. The out-of-class time commitment for each teacher will be about one hour.

The data will be collected by the research team, which includes two faculty members in Education, and three graduate students. All research team members are experienced educators.

Follow-up

Since the study involves the collection of empirical data about teaching strategies that the participants use, the researchers believe the teachers will be interested in receiving a summary of the findings at the conclusion of the study.

Therefore, while all data will remain confidential, the research team will share the final report with the participants.

Research Team

Dr. Al Whitney

Dr. Marv Wideen

Margaret Cusack

Geok Sim Seah

Elaine Barr

APPENDIX B

Approval Letters from School Boards

PHONE 939-9201

SCHOOL DISTRICT No. 43 (COQUITLAM)

550 POIRIER STREET,
COQUITLAM, B.C. V3J 6A7

1979 02 12

Dr. M. Wideen,
Faculty of Education,
Simon Fraser University,
Burnaby, B. C.
V5A 1S6

Dear Dr. Wideen:

Thank you for your February 1st letter, and attachment, in which you outline a research proposal involving the teaching of secondary science.

Approval is given for you to contact the principals of secondary schools in the District to discuss your proposal. Participation, of course, is left to the discretion of individual principals and teachers.

We look forward to any results you are able to share with us.

Yours very truly,

A. K. Mutter,
Assistant Superintendent of Schools.

for:

G. M. Paton,
Superintendent of Schools.

GMP/jn

FEB 1 4 [illegible]

PROFESSIONAL DEVELOPMENT CENTRE
BURNABY SCHOOL BOARD

March 9, 1979

Dr. Marvin F. Wideen,
Faculty of Education,
Simon Fraser University,
Burnaby, B. C.

Dear Dr. Wideen:

As you are aware, the district Research Committee reviewed your research proposal on Teacher Strategies and Change Strategies Of Secondary Science Teachers at a meeting on March 8, 1979. Although there were some questions, your proposal was approved by the committee.

The next step in this project will involve the identification of the actual schools to become involved, and as I understand from your description of the study, this is to be done randomly. Once you have selected the schools you would like to contact, I would appreciate you calling me so that I can attend the meetings with the secondary departments in those schools.

The study is interesting and ambitious and we will try to assist in every way we can. I will look forward to hearing from you.

Yours truly,

Blake Ford
Chairman
Research Committee

BF/il

350 Holdom Avenue, Burnaby, B.C., V5B 3V1 Telephone 299-8464

APPENDIX C

Teacher Questionnaire

SCIENCE TEACHING STRATEGIES
IN JUNIOR SECONDARY SCHOOLS

TEACHER QUESTIONNAIRE

Faculty of Education
Simon Fraser University

The results of this questionnaire will remain strictly confidential. Reporting will involve the total results only; no individual teacher or school will be identified or identifiable in any of the written reports.

Code ____________

ATTITUDES TOWARDS SCIENCE TEACHING

* Part A The following list contains items related to science teaching strategies. Please check the blank by each item which is most representative of your attitude towards that strategy: SA--strongly agree, A--agree, U--undecided, D--disagree, SD--strongly disagree.

ITEM	SA	A	U	D	SD
1. A science teacher should encourage students to critically analyze their own conclusions.	1	2	3	4	5
2. Students should be guided to include articles from different scientific journals in their notebooks.					
3. A secondary science course should include more learning material than a teacher intends to use.					
4. A science teacher should immediately correct a wrong answer given by a student.					
5. Experimental results which cannot be interpreted show that the experiment is not appropriate for secondary science courses.					
6. Students are often capable of designing valid experiments.					
7. Questions which are integrated in the text are confusing to students and should be omitted.					
8. If unexpected results are obtained, they should be included in the analysis of the laboratory work.					
9. Each day's lesson should be based on previous lessons.					
10. Students will learn better when their curiosity is aroused before a subject is studied.					
11. Conflicting data can lead to a useful post-laboratory discussion.					
12. In an investigation students should know from the beginning the steps they will perform.					

ITEM	SA	A	U	D	SD
13. It is desirable to present to students science questions to which answers are not necessarily known.					
14. A secondary science course should have laboratory experiments integrated with the text material.					
15. A student is successful in a laboratory experiment if his results are similar to the class results.					
16. For each new topic, generalizations should be presented before examples and illustrations of the generalizations are provided.					
17. At the end of an experiment, the science teacher should analyze the results to help students understand them.					
18. Textbooks should contain subject matter which could be covered in one academic year.					
19. Scientific journals and reference books should be available for students to use while performing experiments.					
20. One of the roles of the classroom teacher is to present learning situations in such a way that students will raise questions.					
21. Science teachers should make clear in advance all the problems which arise in the performance of a laboratory experiment.					
22. In a science course students should develop skill in interpreting data.					
23. Unstructured activities in the laboratory work may often lead to exciting kinds of science experiences for both the teacher and the student.					
24. Students will perform experiments successfully when the teacher presents an overall explanation of the subject to be investigated.					
25. A primary role of secondary science teachers is to design the investigation to be done.					
26. Science teaching should enable students to identify the assumptions made in a given investigation.					

ITEM	SA	A	U	D	SD
27. By presenting an acceptable rule to students, the teacher avoids the risk of having them arrive at an incorrect one.					
28. A science teacher should prevent his students from trying to critique scientific material before they master it.					
29. A science teacher should be receptive of any reasonable answer a student gives.					
30. Unexpected results should be considered as a part of the laboratory work.					
31. Science teachers should formulate hypotheses when questions are raised by students.					
32. Students should be asked to prepare the equipment needed for laboratory work.					
33. A textbook should contain both the problems to be studied and the answers.					
34. In science class students should learn to make careful and relevant observations.					
35. In general, it is not practical for students to test their own hypotheses.					
36. Teachers, not students, should formulate the problems to be taught in science.					
37. Experimental results that differ greatly from what is expected should not be considered.					
38. Teaching that introduces a scientific problem should sooner or later lead to its solution.					
39. An examination at the end of a science course should ask students to solve problems that they have not seen before.					
40. Differences in data can lead to the proposal of alternative procedures in laboratory work.					

Part B Demographic Data

Training

1. How many courses in science did you take at university?
   1) none 2) 1 to 3 3) 4 to 7 4) 8 or more

2. Did you take any course work at university on science teaching methodology?
   yes _____ no ______

3. How many years have you taught?
   1) 1-3 2) 4-7 3) 8-14 4) 15 or more

   How many years have you taught science?
   1) 1-3 2) 4-7 3) 8-14 4) 15 or more

4. Are you a member of a professional association concerned with science education?
   yes _____ no _____ identify

* Part C Teaching Strategies

The following questions relate to several forms of classroom instruction.

Generally speaking how much time do students spend on the following . Check one for each item.

1.

ITEM	None/ Little	Some	Moderate	Quite a bit	A great deal	Cannot answer
a) Listening to lectures or watching demonstrations						
b) Discussing topics or issues						
c) Working in groups (other than labs)						
d) Working on laboratory exercises when instructions are provided						
e) Working individually on issues and problems which your students organized or initiated e.g. projects						
f) Working individually on issues and problems which you organized						
g) Receiving instructions through audio-visual, printed, or other self-teaching materials						
h) Engaging in role playing or other simulation exercises						
i) Working on lab assignments when the students have to design the procedures						

2. How often do you take your students out of the classroom/lab for a science lesson? State number of times in a school year/one semester.

3. How often do you use teaching strategies that do as little telling as possible?

Part D **Change**

The following questions deal with factors which could influence you to change some aspect of your teaching.

Assume that a new program, in an area relevant to your teaching, has been devised. As a teacher, which of the following is most/least likely to have an impact on changing your teaching in the direction of the new program?

For each item please circle the appropriate response number.

least likely————————most likely
1 -- 2 -- 3 -- 4 -- 5

	ITEM	Least Likely — Most Likely
1)	a new Ministry circular describing the program.	1 -- 2 -- 3 -- 4 -- 5
2)	the principal of your school dictating that you should implement the new program.	1 -- 2 -- 3 -- 4 -- 5
3)	your colleagues discussing the merits of the new program with you and sharing ideas as to its implementation.	1 -- 2 -- 3 -- 4 -- 5
4)	your department head commanding you to implement the new program.	1 -- 2 -- 3 -- 4 -- 5
5)	the School board inviting you to in-service sessions where you will help plan how the new program could best be implemented in your situation.	1 -- 2 -- 3 -- 4 -- 5
6)	a Ministry letter describing the new program.	1 -- 2 -- 3 -- 4 -- 5
7)	you colleagues persuading you of the merits of the new program and that you should implement it.	1 -- 2 -- 3 -- 4 -- 5
8)	your department head explaining the new program to you.	1 -- 2 -- 3 -- 4 -- 5
9)	a Ministry of Education circular instructing you to implement the new program.	1 -- 2 -- 3 -- 4 -- 5
10)	your colleagues implementing the new program.	1 -- 2 -- 3 -- 4 -- 5
11)	the Ministry inviting your participation in workshops where you will give your views as to how the new program should be implemented.	1 -- 2 -- 3 -- 4 -- 5
12)	your principal encouraging you to attend in-service sessions where the new program will be explained.	1 -- 2 -- 3 -- 4 -- 5
13)	your department head inviting you to attend a series of meetings designed to discuss the program's objectives and how they can best be implemented in your school.	1 -- 2 -- 3 -- 4 -- 5
14)	a School Board letter instructing you to implement the new program.	1 -- 2 -- 3 -- 4 -- 5
15)	the principal of your school outlining the program at a staff meeting.	1 -- 2 -- 3 -- 4 -- 5

Code ________

* **Part E** Science Teaching Practices

The following list contains items related to secondary science teaching. Please check the blank by each item which is most representative of your teaching (These items are similar to those in Part A which dealt with attitudes).

1 - very often
2 - often
3 - seldom
4 - infrequently
5 - never

ITEM	1	2	3	4	5
1. My students perform experiments more successfully when I present an overall explanation of the subject to be investigated.					
2. I consider my student successful in his laboratory experiment if his results are similar to the class results.					
3. I make it clear to my students in advance all the problems which may arise in the performance of a laboratory experiment.					
4. I have my students include unexpected results in the analysis of the laboratory work.					
5. I base each day's lesson on previous lessons.					
6. In examinations my students solve problems that they have not seen before.					
7. In science class, my students learn to make careful and relevant observations.					
8. It is not practical for me to make my students test their own hypotheses.					
9. My science course has laboratory experiments integrated with the text material.					
10. In my teaching, when I introduce a scientific problem, it leads sooner or later to its solution.					
11. I formulate hypotheses for my students when questions are raised by my students in class.					
12. I design the investigations to be done.					
13. I encourage my students to critically analyze their own conclusions.					

ITEM	1	2	3	4	5
14. I have scientific journals and reference books available for my students to use while performing their experiments.					
15. I formulate the problems for my students to work on in the science class.					
16. I guide my students to include articles from different scientific journals in their notebooks.					
17. Conflicting data in my class usually leads to a useful post-laboratory discussion.					
18. I ask my students to identify the assumptions made in a given investigation.					
19. I present the generally acceptable scientific rules and laws to students rather than risk having them arrive at an incorrect one.					
20. Our secondary science course includes more learning material than I intend to use.					
21. The textbook contains both the problems to be studied and the answers.					
22. In an investigation my students know from the beginning the steps they will perform.					
23. I encourage my students to propose alternative procedures in laboratory work.					
24. At the end of an experiment, I analyze the students' results to help my students understand them.					
25. I accept any reasonable answer that my students give.					
26. For each new topic, I usually present the generalizations before examples and illustrations of the generalizations.					
27. Questions which are integrated in the text are confusing to my students and should be omitted.					
28. I consider that if the experimental results of my students cannot be interpreted then the experiment is not appropriate for them.					
29. I help my students to develop skill in interpreting data in the science course.					
30. I use unstructured laboratory activities.					
31. Our textbooks contain subject matter which can be covered in one academic year.					
32. I make my students prepare the equipment needed for laboratory work.					

ITEM	1	2	3	4	5
33. In my class, I present learning situations in such a way that my students can raise questions.					
34. I attempt to arouse student curiosity before a subject is studied.					
35. I regard unexpected results as a part of laboratory work.					
36. I do not accept experimental results that differ greatly from what is expected.					
37. I normally present to my students science questions the answers to which are not necessarily known.					
38. I normally prevent my students from trying to critique scientific material before they master it.					
39. I immediately correct a wrong answer given by a student.					
40. I allow my students to design their own experiments.					

APPENDIX D

Student Questionnaire

SCIENCE TEACHING STRATEGIES
IN JUNIOR SECONDARY SCHOOLS

STUDENT QUESTIONNAIRE

Faculty of Education
Simon Fraser University

We will not communicate your individual answers with your teachers.

The results from this questionnaire will remain strictly confidential. Reporting will involve the total results only. No individual student, teacher or school will be identified, or identifiable, in any of the written reports.

Class: ____________

Teacher Code No.: ________

Student Questionnaire

* 1. During an average week of this class (5 - 50 minute periods) what is the amount of time you spend (Check one for each item).

ITEM	None/ Little	Some	Moderate	Quite a Bit	A Great Deal	Cannot Answer
a) Listening to lectures or watching demonstrations						
b) Discussing topics or issues						
c) Working in groups (other than labs)						
d) Working on laboratory exercises when instructions are provided						
e) Working individually on issues and problems which you or your classmates organized or initiated e.g. projects						
f) Working individually on issues which your teacher organized						
g) Receiving instructions through audio-visual, printed, or other self-learning materials						
h) Engaging in role playing or other stimulation exercises						
i) Working on lab assignments for which you have designed the procedures						

* 2. The following items relate to ways in which your science teacher may choose to work with you. Please check the blank by each item which is most representative of what you think happens for you in this class.

SA Strongly agree--this is the way it is almost all the time for me.
A Agree--it is like this some of the time.
U Undecided--I don't really know.
D Disagree--it is very seldom like that.
SD Strongly disagree--I don't think it is ever like that for me.

	ITEM	SA	A	U	D	SD
i)	My science teacher encourages me to critically analyze my own conclusions.					
ii)	I am encouraged to include ideas from different scientific books in my notebook.					
iii)	My science teacher immediately corrects a wrong answer given by us.					
iv)	My science teacher sometimes encourages us to design our own experiments in the laboratory.					
v)	I learn better when my curiosity is aroused before a subject is studied.					
vi)	In an investigation, I know from the beginning the steps I will perform.					
vii)	In science class we sometimes discuss questions to which scientists do not yet know the answers.					
viii)	I am successful in a laboratory experiment if my results are similar to the class results.					
ix)	At the end of an experiment, my science teacher analyzes our results to help us understand them.					
x)	Scientific journals and reference books are available in the laboratory for me to use while I perform my experiment.					
xi)	My science teacher makes clear in advance all the problems which might arise in the performance of a laboratory experiment.					
xii)	My science teacher helps me to develop skill in interpreting data.					
xiii)	My teacher expects me to identify the assumptions I make when explaining experiments or theories.					
xiv)	I perform experiments more successfully when my teacher presents an overall explanation of the subject to be investigated.					
xv)	My science teacher accepts any reasonable answer that I give.					

	ITEM	SA	A	U	D	SD
xvi)	My science teacher forms hypotheses for us when questions are raised by the students in class.					
xvii)	My teacher asks us to prepare the equipment needed for laboratory work.					
xviii)	In my science class, I learn to make careful and relevant observations.					
xix)	I am not able to test my own hypotheses in the laboratory.					
xx)	We are not encouraged to find our own problems to work on in science class.					
xxi)	My teacher does not accept experimental results that differ greatly from what is expected.					
xxii)	My teacher usually has us solve problems that we have not seen before in the examination.					

3. Please think back on the last two weeks of your class and describe briefly some of the learning situations you enjoyed most.

4. What kind of reputation does your teacher have?

5. What kind of reputation would you most like him/her to have?

6. All in all how would you say your teacher does in teaching? Would you say that he/she enjoys great success, some success, average success, less than average success in his/her teaching in this school?

APPENDIX E

Corresponding Items of ISTS instrument.
Part E (Teacher Questionnaire) and
Question 2 (Student Questionnaire)

Table 16

Appendix E: Corresponding items of ISTS instrument (Attitude toward inquiry), Part E of Teacher Questionnaire (Teachers' Perception), and Question 2 of Student Questionnaire (Students' Perception)

Item Nos.					
Part A	Part E	Question 2	Part A	Part E	Question 2
1	13	1	21	3	11
2	16	2	22	29	12
3	20		23	30	
4	39	3	24	1	14
5	28		25	12	
6	40	4	26	18	13
7	27		27	19	
8	4		28	38	
9	5		29	25	15
10	34	5	30	35	
11	17		31	11	16
12	22	6	32	32	17
13	37	7	33	21	
14	9		34	7	18
15	2	8	35	8	19
16	26		36	15	20
17	24	9	37	36	21
18	31		38	10	
19	14	10	39	6	22
20	33		40	23	

APPENDIX F

The Science Teaching Observation Schedule

Coding Sheet

Appendix F: A SCIENCE TEACHING OBSERVATION SCHEDULE

Name .... 20...

Class observed ....

1 *TEACHER TALK*

1a *Teacher asks questions (or invites comments) which are answered by:*

- a_1 recalling facts and principles
- a_2 applying facts and principles to problem solving
- a_3 making hypothesis or speculation
- a_4 designing of experimental procedure
- a_5 direct observation
- a_6 interpretation of observed or recorded data
- a_7 making inferences from observations or data

	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
a_1																					
a_2																					
a_3																					
a_4																					
a_5																					
a_6																					
a_7																					

1b *Teacher makes statements:*

- b_1 of fact and principle
- b_2 of problems
- b_3 of hypothesis or speculation
- b_4 of experimental procedure

b_1																					
b_2																					
b_3																					
b_4																					

1c *Teacher directs pupils to sources of information for the purpose of:*

- c_1 acquiring or confirming facts or principles
- c_2 identifying or solving problems
- c_3 making inferences, formulating or testing hypotheses
- c_4 seeking guidance on experimental procedure

c_1																					
c_2																					
c_3																					
c_4																					

2 *TALK AND ACTIVITY INITIATED AND/OR MAINTAINED BY PUPILS*

2d *Pupils seek information or consult for the purpose of:*

- d_1 acquiring or confirming facts or principles
- d_2 identifying or solving problems
- d_3 making inferences, formulating or testing hypotheses
- d_4 seeking guidance on experimental procedure

d_1																					
d_2																					
d_3																					
d_4																					

2e *Pupils refer to teacher for the purpose of:*

- e_1 acquiring or confirming facts or principles
- e_2 seeking guidance when identifying or solving problems
- e_3 seeking guidance when making inferences, formulating or testing hypotheses
- e_4 seeking guidance on experimental procedure

e_1																					
e_2																					
e_3																					
e_4																					

APPENDIX G

The ISTS Subscales Items

Table 17

Appendix G: The items and reliability coefficients of the Attitude Subscales

Attitude Subscale	Reliability	ISTS Items
A. Need for Structure	0.77	12. In an investigation students should know from the beginning the steps they will perform.
		17. At the end of an experiment, the science teacher should analyze the results to help students understand them.
		24. Students will perform experiments successfully when the teacher presents an overall explanation of the subject to be investigated.
		27. By presenting an acceptable rule to students, the teacher avoids the risk of having them arrive at an incorrect one.
		35. In general, it is not practical for students to test their own hypotheses.
B. The Student as Inquirer	0.72	1. A science teacher should encourage students to critically analyze their own conclusions.
		11. Conflicting data can lead to a useful post-laboratory discussion.
		13. It is desirable to present to students science questions to which answers are not necessarily known.
		20. One of the roles of the classroom teacher is to present learning situations in such a way that students will raise questions.
		30. Unexpected results should be considered as part of the laboratory work.

Appendix G (continued)

Attitude Subscale	Reliability	ISTS Items
C. Instructional Inflexibility	0.63	4. A science teacher should immediately correct a wrong answer given by a student.
		5. Experimental results which cannot be interpreted show that the experiment is not appropriate for secondary science courses.
		12. In an investigation students should know from the beginning the steps they will perform.
D. Laboratory Follow-up	0.54	8. If unexpected results are obtained, they should be included in the analysis of the laboratory work.
		11. Conflicting data can lead to a useful post-laboratory discussion.
		19. Scientific journals and reference books should be available for students to use while performing experiments.
E. Process Skill	0.70	22. In a science course student should develop skill in interpreting data.
		30. Unexpected results should be considered as a part of the laboratory work.
		34. In science class students should learn to make careful and relevant observations.
		40. Differences in data can lead to the proposal of alternative procedures in laboratory work.

APPENDIX H

Choice Distribution of the Junior Secondary Science Teachers Responding to the ISTS Items

Table 18

Appendix H: Choice Distribution of the junior secondary science teachers responses to the ISTS items

Item No.	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
+ 1	13	7	1	-	-
+ 2	2	9	9	1	1
+ 3	10	9	2	-	1
4	-	8	2	12	-
5	3	4	6	6	3
+ 6	3	8	6	4	-
7	-	6	4	7	4
+ 8	12	10	-	-	-
9	1	7	4	9	1
+10	12	8	1	1	-
+11	9	11	2	-	-
12	9	8	5	-	-
+13	8	9	2	3	-
+14	12	10	-	-	-
15	-	8	2	8	3
16	-	8	5	9	-
17	5	11	4	2	-
18	-	5	7	9	1
+19	3	15	2	2	-
+20	10	12	-	-	-
21	4	8	2	8	-
+22	10	12	-	-	-
+23	4	11	4	3	-
24	3	4	8	7	-
25	-	4	4	11	3
+26	2	14	4	2	-
27	1	6	7	7	1
28	-	1	3	15	2
+29	11	10	-	1	-
+30	10	11	1	-	-
31	2	11	2	5	1
+32	1	6	9	5	-
33	1	7	3	8	2
+34	13	9	-	-	-
35	1	7	3	7	3
36	3	8	3	8	-
37	-	1	3	10	8
38	2	9	4	7	-
+39	1	11	3	6	1
+40	5	13	3	1	-

Items which are favorable toward inquiry are marked (+) before the item number.

APPENDIX I

Percentage Use of the STOS Subcategories by the Junior Secondary Science Teachers

Table 19

Appendix I: Percentage Use of the 23 STOS subcategories by the junior secondary science teachers

Subcategories	Teacher Number										
	1	2	3	4	5	6	7	8	9	10	11
a_1	12.2	38.8	10.4	3.4	12.9	11.9	2.4	7.6	13.0	14.8	4.5
a_2	4.6	11.4	4.3	1.1	4.9	4.5	0.7	0.9	6.7	8.6	0.8
a_3	-	-	2.0	-	3.3	4.3	-	3.6	3.2	2.5	-
a_4	-	-	8.2	3.3	1.5	-	-	3.5	0.8	3.6	1.2
a_5	-	2.4	3.9	1.1	8.1	11.2	-	4.1	-	2.6	0.6
a_6	-	-	6.0	2.2	-	-	2.4	2.0	1.7	1.2	0.8
a_7	-	-	3.1	-	-	-	2.4	1.3	1.7	1.2	-
b_1	36.8	30.4	16.0	22.0	12.6	15.6	2.2	11.4	35.6	8.6	15.6
b_2	-	-	-	-	1.6	1.2	3.5	1.3	-	-	0.8
b_3	-	-	1.0	-	-	-	1.1	-	-	-	-
b_4	1.9	-	16.5	23.0	12.9	15.6	14.3	8.6	4.0	10.9	12.1
c_1	3.4	-	1.5	3.5	4.9	0.7	1.1	2.9	11.4	3.7	2.1
c_2	-	1.4	-	8.3	1.6	1.4	-	-	-	-	-
c_3	-	-	-	-	-	-	-	0.7	-	-	0.6
c_4	-	-	-	3.3	2.9	0.7	0.7	2.1	-	-	1.3

Appendix I (continued)

Subcategories	Teacher Number										
	1	2	3	4	5	6	7	8	9	10	11
d_1	10.5	8.5	2.0	-	-	-	5.5	8.7	4.4	5.1	15.9
d_2	3.2	2.9	1.5	19.0	3.3	12.1	22.4	2.8	2.4	10.9	2.4
d_3	-	-	-	-	2.9	3.6	7.6	7.4	-	-	3.1
d_4	1.9	-	3.8	1.1	17.2	10.0	15.6	15.1	0.8	12.5	11.8
e_1	23.6	2.4	3.6	2.2	-	5.8	-	6.1	12.7	3.8	16.4
e_2	1.1	1.9	9.0	2.2	-	3.3	7.4	1.3	0.9	2.4	0.8
e_3	-	-	0.6	1.1	1.5	-	3.3	5.4	-	-	1.9
e_4	0.9	-	6.8	3.2	8.6	5.5	7.2	2.4	0.8	7.5	7.2

Percentages may not equal 100 owing to rounding.

Appendix I (continued)

Subcategories	Teacher Number										
	12	13	14	15	16	17	18	19	20	21	22
a_1	7.4	5.4	15.4	4.7	1.8	14.9	8.4	4.2	14.4	7.7	11.3
a_2	3.3	3.5	2.3	6.9	1.0	10.3	12.7	10.6	4.8	11.3	1.8
a_3	2.6	-	2.3	2.3	-	3.2	-	0.8	3.1	2.3	0.7
a_4	1.5	2.5	1.0	-	-	0.8	-	-	-	0.6	-
a_5	2.7	1.0	-	5.2	-	9.1	1.9	2.3	3.7	2.3	1.1
a_6	0.9	2.2	-	4.3	1.0	3.5	0.9	1.0	0.6	5.9	-
a_7	-	-	-	2.3	-	3.2	-	-	0.6	3.2	-
b_1	20.8	24.1	33.8	8.4	19.3	34.6	11.6	21.6	25.1	14.3	30.7
b_2	1.2	6.7	-	0.7	-	-	3.4	0.7	0.6	0.7	-
b_3	-	-	10.0	-	-	-	-	-	0.6	-	-
b_4	13.7	11.1	7.6	5.8	19.5	7.2	7.6	6.0	6.0	-	5.7
c_1	7.5	3.7	-	2.5	-	2.7	1.9	3.3	3.6	1.5	1.8
c_2	2.4	3.0	1.0	4.0	-	3.4	5.8	2.5	0.9	1.5	-
c_3	-	1.0	1.0	-	-	-	-	-	-	-	-
c_4	1.8	2.2	5.5	4.0	-	-	2.2	1.7	4.3	0.7	2.5

Appendix I (continued)

Subcategories	Teacher Number										
	12	13	14	15	16	17	18	19	20	21	22
d_1	11.0	2.0	6.8	14.2	12.9	0.9	7.4	0.7	9.6	7.2	19.6
d_2	4.2	12.7	2.1	8.0	-	-	13.9	18.8	-	16.9	-
d_3	-	1.2	-	4.8	-	-	-	0.8	-	-	-
d_4	3.6	7.4	9.4	4.5	16.9	-	11.9	6.5	6.8	6.1	11.2
e_1	7.8	3.0	6.5	9.3	13.1	5.4	2.7	-	12.2	2.7	11.7
e_2	0.6	3.7	-	2.8	-	-	5.5	10.4	-	11.2	-
e_3	-	1.0	1.0	1.9	-	0.8	-	-	1.2	-	-
e_4	5.3	2.5	3.1	3.8	14.4	-	2.1	3.9	1.7	4.0	1.8

Percentages may not equal 100 owing to rounding.

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