THE RELATIONSHIP BETWEEN STUDENT ATTITUDE TOWARD GRADE 10 SCIENCE AND CLASSROOM LEARNING ENVIRONMENT VARIABLES

by

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Abstract

The general problem was to investigate theoretical and empirical relationships between student attitude toward Grade 10 science and classroom learning environment variables and to use these findings interpretively to design a teaching/learning strategy which could be used to improve student attitudes. This investigation sought to answer three questions:

1. How is student attitude toward the subject science acquired, changed, and related to variables within a science classroom learning environment? A description of these associations was based upon an analysis of the writings of Ajzen and Fishbein (1980) and Haladyna et al. (1983).

2. What is the nature and strength of the empirical relationship between student attitude toward Grade 10 science and classroom learning environment variables? This determination was accomplished in two ways. The first way involved the possibility of obtaining a linear relationship between a dependent measure of student attitude toward Grade 10 science and a composite of independent learning environment variables. The second way involved the gathering and analysis of student ideas about this relationship using an interview technique.

3. How can the results of this study be used interpretively to improve student attitudes toward Grade 10 science? The focus here was to design a teaching/learning strategy which could be used by the classroom teacher in order to improve student attitudes based upon some of the theoretical and empirical relationships revealed in this study.

In the first question it was found that the Haladyna model of variables that could influence student attitudes and the Ajzen and Fishbein view of attitude and attitude change could be interpreted and applied in an educational context to assist in the provision of a perspective on a problem in teaching practice -- mainly how can learning environment variables be manipulated in an attempt to

improve student attitudes.

In the empirical question it was found that a linear relationship existed between measures of student attitude toward Grade 10 science and student beliefs about their classroom learning environment. A forward regression analysis revealed that three variables accounted for 28.9% of the measured variance in student attitude. These variables, in decreasing order of significance of contribution, were: a) Satisfaction (extent to which students are satisfied with the work of the class; b) Apathy (extent to which students care about the class); and c) Difficulty (extent to which students find the class difficult).

Personal interviews of 16 Grade 10 science students revealed other learning environment variables which were related to student attitude toward Grade 10 science. These variables, in order of salience, were the: a) extent to which there are hands on activities, b) clarity and organization of teacher explanations, c) perceived usefulness of the science knowledge d) degree of difficulty of the subject and e) quality of interpersonal relationships in class.

Interviews of teachers and students also provided additional suggestions as to how to promote more positive student attitudes. Some of the more frequently mentioned suggestions were: a) more labs and hands on activities, b) less teacher talk, c) more emphasis on the practical/social/personal aspects of science content, d) more teacher enthusiasm to promote science as a valuable activity, and e) to have as great a variety of science activities as possible.

The third question involved design of a teaching/learning strategy based on a format for the application of theory to educational practice suggested by Joyce and Weil (1980). This strategy, which involved the manipulation of the learning environment in accordance with the Ajzen and Fishbein theory, was illustrated by a sample lesson from a unit of instruction developed by the researcher.

Table of Contents

List of Tables

List of Figures

List of Appendices

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Chapter 1

INTRODUCTION

The classroom learning environment, which involves interactions among students, beween students and the teacher, and between students and the subject matter taught, has been thought to be important in terms of both the quality of the educational process and ensuing student learning outcomes (Fraser, Anderson, & Walberg, 1982; & Walberg & Haertel, 1980). One of these learning outcomes, positive student attitudes toward the subject, may be influenced by variables within a classroom learning environment (Haladyna, Olsen, & Shaughnessy, 1982; & Lawrenz, 1976a). The promotion of positive student attitudes toward science has been a common goal for science education programs (Jones & Butts, 1983; Macmillan & May, 1979; & Towse, 1983).

Given the expressed importance of positive student attitudes toward science as a school subject and the likely relationship between these attitudes to variables within a science classroom learning environment, the general goal of this study was to learn more about this relationship. Schibeci (1984), in an extensive review of attitude toward science research, indicated specifically the need for a study like this. He noted

> Studies of the association between school variables such as the learning environment and attitudes to science were not as plentiful as one would expect. It is reasonable to expect that this class of variables would have a significant influence on attitudes, and that more studies of classroom climate in science classrooms would be fruitful. (p. 38)

This study was an attempt to respond to this need in order to improve classroom practice in science teaching.

1.1 STATEMENT OF THE PROBLEM

1.1.1 GENERAL STATEMENT OF THE PROBLEM

The general problem of this study was to investigate theoretical and empirical relationships between classroom learning environment variables and student attitude and to use these findings interpretively in order to design a teaching/learning strategy to improve student attitudes toward the subject of Grade 10 science.

1.1.2 RESEARCH QUESTIONS

1. How are student attitudes toward the subject science acquired and changed and how are these attitudes related to variables within a science classroom learning environment? The focus here was on describing a theoretical notion of this relationship based upon the writings of Ajzen and Fishbein (1980) and Haladyna et al. (1983).

2. What is the nature and strength of the relationship between student attitude toward Grade 10 science and classroom learning environment variables? The focus here was on determining whether or not an empirical relationship existed between student attitudes and classroom learning environment variables, and if it did, what was the strength of this relationship. This determination was accomplished in two ways. The first way involved the possibility of obtaining a linear relationship between a dependent measure of student attitude toward the subject science and a composite of independent learning environment variables. The second way involved the gathering and analysis of student ideas using an interview technique.

3. How can the results of this study be used interpretively to improve student attitudes toward the subject science? The focus here was on designing a teaching/learning strategy which could be used by the classroom teacher in order to improve these attitudes based upon the theoretical and empirical relationships revealed in this study.

1.2 DESCRIPTION OF TERMS

The following terms and phrases were central to the investigation of the problem.

1. Classroom Learning Environment- "the interpersonal relationships among pupils, relationships between pupils and their teacher, relationships between pupils and both the subject matter studied and the method of learning, and, finally, pupils perceptions of the structural characteristics of the class" (Fraser, Anderson, & Walberg 1982, p. 2). The classroom learning environment variables which were investigated in this study were those described in the Learning Environment Inventory (LEI), (Fraser, Anderson, & Walberg, 1982). Some examples of these variables included the formality, goal direction, and favoritism in the class. Other learning environment variables were also defined in an analysis of student and teacher interview data.
2. Attitude- a learned predisposition of an individual to respond, in a consistently favorable or unfavorable way, to performing behaviors related to an attitude object (Ajzen & Fishbein, 1980; Fishbein, 1967; & Fishbein & Ajzen, 1975).

3. Attitude Toward the Subject Science - a learned predisposition of an individual to respond, in a consistently favorable or unfavorable way, to performing behaviors related to the teaching/learning of the subject science. The subject Grade 10 science was defined by the guidelines for curriculum and instruction in the Junior Secondary Science curriculum guide for the Province of British Columbia (1983).

1.3 RATIONALE AND BACKGROUND

1.3.1 THE IMPORTANCE OF THE PROMOTION OF POSITIVE ATTITUDES TOWARD THE SUBJECT SCIENCE

One of the major goals or objectives for science education programs has been to foster more positive student attitudes toward both science as a school subject and the scientific enterprise in general. Numerous science educators and researchers have noted that these attitudinal goals or objectives were prevalent or very important in science education (Abraham, Renner, Grant, & Westbrook, 1982; Ayers & Price, 1975; Birnie, 1978; Comber & Keeves, 1973; Doran, Guerin, & Cavalieri, 1974; Eggen, 1978; Fraser, 1978d; Klopfer, 1971; Koballa & Crawley, 1985; Lawrenz, 1975; Lowery, Bowyer, & Padilla, 1980; MacMillan & May, 1979; Johnson, Ryan, & Schroeder, 1974; Schibeci, 1984, 1986; Towse, 1983; Vitrogan, 1967; Voss, 1983; Ward, 1976; & Yager & Penick, 1984). The position put forward by MacMillan and May (1979) cogently represented the importance and prevalence of attitudinal objectives for science education programs. They asserted that "there has always been an interest in the development of positive pupil attitudes toward science. The objective of any science curriculum includes fostering favorable feelings toward science as well as imparting cognitive knowledge" (p. 217). Simpson, Renz, and Shrum (1976) added further support to the importance of attitudinal learning outcomes in their assertion that "feelings, attitudes, and values our students take from the science courses may be of more consequence - both immediately and ultimately - than anything else the curriculum embodies" (p. 280).

The importance of student attitudes to science educators was also evident in the quantity of research done in the area. Schibeci (1984), in an update of attitude toward science research, noted that 17% of the papers presented at the National Association for Research in Science Teaching 1983 meeting were related to student attitudes. Munby (1980), in a review of the quality of attitude measuring instruments, located more than 2,000 references related to the topic of attitudes in science education in a ten year period spanning from 1967-1977. Peterson and Carlson, (1979), in their review of science education literature, noted that there were about 30 published attitude studies a year for the years 1972-1976. Based on this quantity of research it could be inferred that the consideration of student attitudes was important to both science educators and researchers.

Further support for the importance of attitudinal goals has also been indicated by the Science Council of Canada (1984) report and the British Columbia Junior Secondary Science curriculum. In the case of the British Columbia curriculum, teachers are asked to direct 25% of their teaching toward the promotion of positive student attitudes. In addition to this request the Science Council of Canada, in their report on Science for Every Student (1984), recommended that "teachers and curriculum planners must evaluate students' progress towards all the goals of science education, not just their learning of scientific content" (p. 1).

Reasons Why Positive Student Attitudes Are Important

One of the major arguments for the promotion of positive attitudes involved the suggestion that there is a strong relationship between student attitude toward the subject science and science achievement (Eisenhardt, 1977; Dutton & Stephens, 1963; Hasan & Billeh, 1975; Osborne, 1976; Russell & Hollander, 1975; & Vitrogan, 1967). The general argument presented was that if students have positive attitudes toward the subject then they will learn or achieve better.

Mager (1968) extended this achievement argument to claim that attitudes affected not only present learning but also future learning. He asserted that

> the likelihood of the student putting his knowledge to use is influenced by his attitude for or against the subject. Things disliked have a way of being forgotten .... One objective toward which to strive is that of having the student leave your influence with as favorable an attitude toward your subject as possible. In this way you will help to maximize the possibility that he will remember what he has been taught, and will willingly learn more about what he has been taught (p. 311).

It was inferred, based upon personal experience and the review of literature done by Fraser (1982), that students often claim they do better in subjects they had a positive attitude toward. The question of whether they actually do, however, is one of contention. Empirical evidence for an attitude-achievement connection, for the most part, has shown that there is an association (Willson, 1980; & Fraser, 1982). However, some studies also indicated that this association may not be as strong as some students and science educators believe (Napier & Riley, 1985; & Willson, 1983).

Some science educators also argued, based on their experiences and beliefs, that student attitudes are significant in terms of the "citizens" we send out from our science classrooms (Ayers & Price, 1975; Hasan, 1975; Schock, 1973; & Wareing, 1982). Moreover, Hasan (1975), Ayers and Price (1975), and Schock (1973) argued that positive attitudes were also important for the development of scientifically literate citizens, which they believed to be an important student learning outcome. Other positions have also been put forward which involved the argument that positive attitudes toward science increased the likelihood students would pursue science related careers (Hasan, 1975; & Gardner, 1976). Payne (1977) pursued the issue of future benefits of positive attitudes even further in his assertions that attitudes influenced a person's ability to "participate actively in a democratic society" and were "necessary for a healthy and effective life" and interacted with "occupational and vocational satisfaction" (pp. 66-67).

In general, the literature appeared to claim that positive student attitudes toward the subject science are desirable and influence future student attitudes and behaviors with regard to the scientific enterprise. However, more caution may be considered before making specific claims, as Payne (1977) did, about these future relationships. The issue of whether or not a relationship exists is clearly one which needs further investigation.

If there is an association between our present students' attitude toward the subject science and their future learnings, hobbies, and careers, then the selection of the Grade 10 level as a focus for study has some significance. The significance may be found in the fact, that in many parts of Canada, Grade 10 science is the final compulsory science course. Therefore, student attitudes toward this subject may be a factor in terms of student desires to pursue further science courses or science related career options.

Student attitudes toward the subject science have also been considered important because of direct implications for teachers. For example, Newton (1975), based on his analysis of science teaching practice concluded that "negative attitudes in the classroom can make actual teaching complex and frustrating" (p. 370). Furthermore, if attitudes are learned, as some learning and attitude theorists (Ajzen & Fishbein, 1980; Fishbein, 1967; Festinger, 1957; Hovland & Rosenberg, 1960, Lewin, 1951; Krathwohl, Bloom, & Masia, 1964; Thurstone, 1931; & Osgood, Suci, & Tannebaum, 1957) and science educators (Aiken & Aiken, 1969; Koballa, 1983; Koballa & Crawley, 1985; & Shrigley, 1983) have argued, then teachers may have a profound influence on their students' attitudes. MacMillan and May (1979), based upon their analysis of junior high student interview data, supported the importance of the teacher's role in promoting positive attitudes toward their subject. They asserted that

> it is refreshing to find how much influence the teacher has on attitude development. Teacher personality, relations, and interactions with pupils, classroom activities, rewards, assignments, and pupil work were all directly controlled by the teacher. Thus the teacher must assume a large part of both the responsibility and challenge of developing positive attitudes of students toward science (p. 221).

1.3.2 THE IMPORTANCE OF THE CLASSROOM LEARNING ENVIRONMENT

The science classroom learning environment was viewed as a likely source of variables which influence student attitudes toward the subject science. This view was taken based upon the review of related literature and the suggested association between them proposed by Haladyna et al. (1982, 1983).

The importance of promoting a positive science classroom learning environment, and the likely relationship between this environment to student attitudes toward the subject science, added salience to the comment of Walberg and Haertel (1980). They suggested that positive classroom learning environments and student learning outcomes (such as positive student attitudes) go together. Moreover, they asserted " It appears that constructive climates and valued educational accomplishments generally go together, and the same kinds of environment were indicated regardless of which aim is exposed" (p. 232). Ramsey (1974) extended this importance in terms of the success of our programs. He stated that

> Yet the success or otherwise of science instruction could be assessed with equal validity by focussing on the instructional process itself rather than the outcomes. To focus only on outcomes is rather like testing steel by determining its composition at the end of a run without monitoring the production process (p. 95).

Given the preceding arguments for the importance of the classroom learning environment in the promotion of positive learning outcomes, this study may be significant in terms of obtaining both specific information from students about what their classroom learning environments were like and what it was in the environment that promoted more positive attitudes toward the subject science. Further support for gathering this type of information was evident in the literature (Cooper & Cooper, 1976; Cooper & Petrosky, 1974; Haladyna et al., 1982; Hofstein et al., 1979; Mayer & Richmond, 1982; & Walberg & Haertel, 1980). Futher, Moos (1980) stated that "students were a good source of information about a class, since they have encountered many different learning environments, were in a class for many hours and have enough time to form accurate impressions of the classroom milieu" (p.240). Cooper and Petrofsky (1974) also came to a similar conclusion in their investigation which involved over 700 essays written by science students. They concluded that their findings demonstrated "that students were unusually perceptive about their science teacher and the classroom climate for learning and that these perceptions have important implications for instruction" (p. 24). Finally, Power (1977) suggested that the gathering of information from classroom participants, as was the case in this study, was relevant information because "it follows that to understand what is happening it is necessary to see the situation from the point of view of the participants" (p. 21).

If teachers have some control over their own classroom environment, as was suggested in the literature, (DeYong, 1977; Haladyna & Shaughnessy, 1982; Hofstein et al., 1979; Lawrenz, 1976a,b; Randhawa & Fu, 1973; & Tjosvold & Santamaria, 1978), then teachers may be able to initiate actions to change the environment. A particularly significant finding by DeYong (1977) revealed that specific student perceptions of the classroom learning environment, as measured by the widely used Classroom Environment Scale (Moos & Trickett, 1974), could be changed through instruction and specific materials. Furthermore, Sharan & Yaakobi (1981) also found in a study of urban and rural differences in learning environments, that a more positive social climate could be promoted through instruction. Lawrenz (1976a) supported the importance of classroom learning environment variables because "they do represent an important subset of variables which can be manipulated by educators in attempting to improve students' science attitude" (p. 513). This study was relevant to practice because it considered variables which could be controlled in a teaching situation and provided suggestions as to how these variables could be manipulated.

In the literature, there were also suggestions that teacher knowledge of their learning environment and attempts to improve it may have other positive implications for improving teaching practice. For example, some science education researchers have suggested or found that attempts to improve the classroom learning environment may be a factor in terms of teacher: self improvement (Lawrenz, 1975); self analysis (Hofstein et al., 1982); increased teacher motivation (DeYong, 1977); and improved selection of appropriate instructional methods (Hofstein et al., 1979; Fraser, 1981a; Haukous & Penick, 1983; & Randhawa & Fu, 1973). Moreover, teacher initiated actions may help promote a higher probability for the attainment of stated objectives (Herron & Wheately, 1974), and generally promote better science classrooms (Fraser, 1981a; & Fraser & Fisher, 1982). Some of the variables which were important in terms of improving student attitudes toward the subject science were identified in this study. Teacher attempts at altering these environments, such as those suggested in the design of the teaching/learning strategy, may enhance the individual teachers' personal and professional development.

In summary, the literature reviewed suggested that teachers need to know more about the science classroom learning environment (Kahle & Yager, 1981; Lowery, 1980; Tjosvold & Santamaria, 1978; & Yager, 1978) and that teachers play a key role in establishing this environment (Hofstein et al., 1979; Lawrenz & Welch, 1983; Power, 1977; & Whitfield, 1979). Moreover, improving the classroom learning environment has been deemed important in terms of improving the science education process (Kahle & Yager, 1981; & Walberg, 1984) and student attitudes toward the subject science (Lawrenz, 1976a,b).

1.3.3 INTENDED CONTRIBUTIONS OF THIS STUDY TO SCIENCE EDUCATION

Previous sections have focussed on the rationale and background of both attitude toward the subject science and classroom learning environment research. Moreover, possible contributions of this study to educational research and practice were also suggested. Other intended contributions in the areas of applied theory, methods of research, and knowledge are discussed in this section.

Applied Theory

One possible contribution of this study involves the description and analysis of the Ajzen and Fishbein (1980) attitude theory in a science education context. This theory was utilized to describe how attitude is acquired, changed, measured, and related to behavior. A major concern of previous attitude toward science research involved the lack of specified foundations to provide a frame of reference for results and conclusions of studies (Messick, 1975; Munby, 1983; Munby, Kitto, & Wilson, 1976; Nagy, 1978; Shrigley, 1983; & Steiner, 1980). In response to this criticism, this theory was used in order to provide an example of how a particular theory could guide a study concerned with the teaching for positive student attitudes. Perhaps if researchers can adopt a consistent theoretical framework, such as this one, then greater progress may be made towards more consistent and meaningful results in succeeding attitude research.

The development and use of theoretical foundations for science education research was supported by Gauld and Hukins (1980) in their assertion that

> progress in research is not always made by many people doing a lot of different things, but may be better achieved by groups which adopt a particular theoretical framework and then spend a great deal of effort carrying out investigations within that framework. This provides a coherence which is lacking in most of the research reported over the past 60 years in the science education literature (p. 153).

In this study, a theoretical foundation was not only described in an educational context. Additional steps were suggested to further apply this theoretical perspective to a problem of practice - mainly how can Grade 10 science teachers improve student attitudes toward the subject science. This application involved the interpretation of a theoretical notion of attitude in order to design a teaching/learning strategy which could be used to improve these attitudes. This application of theory to practice was one of expressed need (Joyce, 1978 ; & Joyce & Weil, 1980).

Research Methods

This study also intends to improve upon previous science education research in the area of student attitudes. For example, it addressed some of the concerns expressed in the literature with regard to the lack of quality in this research (Gauld & Hukins, 1980; Mallinson, 1977; Munby, 1980; Pearl, 1973; & Peterson & Carlson, 1979). Some of the suggested improvements included: the need for a clear deliniation of constructs to be investigated, the need for more careful selection and use of instrumentation, and the need for more innovative techniques to investigate variables that influence student attitudes.

In terms of the clarification of constructs to be investigated, both conceptual and operational definitions of the meaning of an attitude toward the subject science were provided. These definitions were based on a theoretical foundation outlined by Ajzen and Fishbein (1980).

Numerous concerns were noted with regard to the instruments used to collect attitudinal data (Anderson & Herrera, 1976; Bratt, 1984; Butts, 1983; Champlin, 1970; Gabel, Rubba, & Franz, 1977; Gardner, 1975a,b; Comber & Keeves, 1973; Munby, 1980; Pearl, 1973; Peterson & Carlson, 1979; Schibeci, 1983, 1984; Ost & White, 1976; & Wilson, 1981). Some of the specific concerns included the need for both verification of instrument reliability and validity, and generally closer adherance to established psychometric procedures. Although criticisms of attitude instruments were prevalent, Munby (1980) believed that "there is nothing substantial or insurmountable which might otherwise impede efforts to improve instrumentation" (p. 273). Klopfer (1981), in his editorial comments on assessment instruments in science education, gave further support for continued efforts to improve instrumentation. He asserted

> Although it is not certain that everything of importance in science education can be readily measured, the continuing effort to broaden the range, enhance the usefulness, improve the precision, and increase the sophistication of assessment instruments and techniques is clearly worthwhile (p. 117).

In the this study, consideration was given to the development of an improved instrument to assess student attitude toward the subject science.

This study also had some innovative qualities that may provide insights into new research questions. For example, one question investigated involved the determination of classroom learning environment variables that Grade 10 science teachers reported they could control in a teaching situation. If there was a reasonably strong relationship between some classroom learning environment variables and student attitude, it was deemed important to identify variables which were relevant to science teachers. This identification was useful in that there may be a higher probability that teachers can initiate actions to produce changes in these variables.

The procedure used for the determination of these relevant variables, from the most widely used instrument in the area, the LEI, provided a viable method by which to select variables for investigation. In the review of literature there were no studies found which utilized a report system in order to determine which variables would be investigated before data was collected. Support for this selection procedure was given by one of the founders of classroom learning environment research as we presently know it. Dr. Herbert J. Walberg (1984), stated that "more work needs to be done (in the selection of appropriate variables) in that area". (Walberg, personal communication February, 1984). This study then was somewhat innovative in that it considered a technique which was not considered in previous research.

In addition to the identification of teacher controllable variables, the study also incorporated an interview to supplement and expand upon regression analysis data which were used to identify learning environment variables which influenced student attitudes toward the subject science. One criticism of previous research was with regard to the over reliance on pencil and paper assessment instruments to provide information on student attitudes toward science. Some science educators have suggested that attempts could be made at a more innovative type of research into student attitudes (Aiken & Aiken, 1969; Gardner, 1975a,b; & Moyer, 1975). Moreover, some researchers advocated the use of an interview technique (Doran et al., 1974; Gardner, 1975a; Lutz & Ramsey, 1974; Russell & Hollander, 1975; & Simpson et al., 1976).

Within the design of the present study, there were student interviews in conjunction with paper and pencil assessments of student attitudes and the classroom learning environment. Support for this combined approach was given by Gardner (1975a) who asserted that "much of the research on attitudes has employed traditional psychometric paradigms which yield general statements based on average data.... We need more studies which were simultaneously objective (i.e., based on hard data) and idiographic (i.e., based on individual cases) (p. 31).

<u>Need for Further Knowledge</u>

In spite of the criticisms of science attitude research, there were also statements of support for continued research (Leece & Mathews, 1976; Moyer, 1975; Peterson & Carlson, 1979; Shrigley, 1983; & Simpson et al., 1976). Shrigley (1983), in a review of the attitude concept, articulated the need for further research. He stated that

> Historically, attitude has been difficult to operationalize within educational research. It appears inconsistent, even fickle, tempting some

> to abandon the concept, even to deny its existence. We could succumb to the temptation of placing it on the periphery of educational research giving priority to the cognitive domain where measurement is simpler. But attitude is central to human action (p. 425).

This study represents a further effort to gain a better understanding of how attitudes can be defined, changed, and measured in a science education context.

There were also calls for further research into variables that may influence student attitudes toward the subject (Doran et al., 1974; Fraser, 1977; Haladyna & Shaughnessy, 1982; Haladyna et al., 1982; Moyer, 1975; and Simpson et al., 1976). Of particular significance was the assertion made by Haladyna et al. (1982), who based on their meta-analysis of research in the area concluded, "the lack of integrative findings has created a situation where not much is known of the possible determinants of attitudes toward the subject of science" (p. 672). In spite of these previous problems in the identification of possible determinants of student attitudes, Peterson and Carlson (1979) asserted that

> we ought to be able to determine whether there were some elements which influence attitudes positively or negatively, and then perhaps develop ways to promote positive attitudes on an individual basis, and ways to treat those negative attitudes which somehow develop (p. 501).

This study attempted to identify possible determinants of student attitude toward Grade 10 science. Moreover, this identification of variables was relevant in that it involved only those variables which teachers reported they could potentially control in a teaching situation.

1.4 OVERVIEW OF THE METHOD OF STUDY

The following overview is intended to provide an outline of the steps involved in the investigation of the problem. These steps are outlined in greater detail in chapter 3.

1. A theoretical notion of how attitude is defined, measured, acquired and changed and how attitudes toward the subject science could be related to variables within a classroom learning environment was described. With this notion providing a perspective on the study, data was collected to determine if empirical relationships existed between measures of classroom learning environment variables and student attitude toward the subject science as taught at the Grade 10 level.
2. A sample of 245 Grade 10 science students, from the Kamloops School District in the province of British Columbia, was made available for participation in the study.
3. Instruments, which included the Learning Environment Inventory, LEI, (Fraser, Anderson, & Walberg, 1982); the Attitude Toward the Subject Science Scale, ATSSS; the Classroom Factors that Influence Influence Student Attitude interview schedule; and the Learning Environment Inventory Analysis, LEIA; were analyzed for their appropriateness for this investigation.
4. The degree of reported teacher control over classroom learning environment variables from the LEI was determined via the analysis of responses to the LEIA by 20 Grade 10 science teachers from the District.
5. Both the ATSSS and the selected variable scales from the LEI were administered by the researcher to the sample of students.
6. A forward regression analysis was undertaken to determine which LEI measured independent variables were the best predictors of variance in

ATSSS measured student attitude toward the subject science.

7. Sixteen students from the sample were interviewed by the researcher using the Classroom Factors that Influence Student Attitude schedule. This interview was designed to gather further information on student ideas about classroom learning environment variables that influenced student attitude toward the subject science.
8. Fifteen volunteer teachers from the district were interviewed using an informal technique. This interview was designed to gather information on what teachers could do in their classroom learning environment to promote more positive student attitudes toward the subject science.
9. The regression, interview, and correlational data were compiled, analyzed, and interpreted.
10. Based on the intepretation of these results inferences for educational theory and practice were drawn, and recommendations for future research suggested. An important aspect of the interpretation involved the design of a teaching/learning strategy which could be used by Grade 10 science teachers in an attempt to improve student attitudes toward the subject.

1.5 LIMITATIONS OF THIS STUDY

There were a number of practical constraints which limited the scope and validity of the results of this study.

The scope of this study was limited by the complexity of the relationships investigated. For example, the Ajzen and Fishbein (1980) theory in its totality attempts to explain and predict human behavior in particular situations. Although the fundamentals of this theory were outlined, the focus of this study was to investigate only one apsect of it - student attitude and its relationship to variables in a classroom learning environment. Another limitation in scope involved the identification of classroom learning environment variables which were related to student attitudes toward Grade 10 science. Some significant relationships were identified, however, it was unlikely all were. Finally, the scope of the study was limited by the time, resources and sample available for data collection. For example it was not feasible to use random selection of students, survey those students not present at the time of the administration of instruments, or to screen for the reading or comprehension ability of the respondents.

There were also other limitations in terms of the validity of the results of the study. For example, personal judgments were used in the analysis of the interview responses from both students and teachers. There may also have been an unintentional researcher bias present in the interpretation and recording of these responses. The interviews, however, were used to supplement and add to the empirical regression information about variables that may be related to student attitude toward Grade 10 science. This additional information was gathered with the intention of making the study more relevant to educational practice.

There were also limitations in terms of the generalizability of the empirical results of the study. These results apply to the population of Grade 10 science students within the Kamloops School District. However, the researcher would like to suggest that these results may have some educational significance for other populations with similar science programs.

Chapter 2

REVIEW OF THE LITERATURE

This review includes a description of both the theoretical perspective used in this study as well as a summary of major findings of previous relevant research.

The theoretical perspective included a description of both the Haladyna et al. (1983) model of variables that could be related to student attitudes toward the subject science and the Ajzen & Fishbein (1980) attitude theory. The Haladyna model provided a general perspective on possible variables that could influence these attitudes. The Ajzen and Fishbein theory provided a more detailed perspective on how these attitudes are acquired, changed, and related to behavior. Based on the work of these researchers a theoretical notion of the relationship between student attitudes toward the subject science and variables within a science classroom learning environment was abstracted and described.

The review of related research involved an examination and analysis of significant findings, conclusions, and problems from research concerned with attitude or the classroom learning environment. Within this examination and analysis, possible contributions of this study to both the body of knowledge about student attitude toward the subject science and science education practice were suggested.

2.1 THEORETICAL PERSPECTIVE

2.1.1 OVERVIEW OF THE HALADYNA ET AL. MODEL

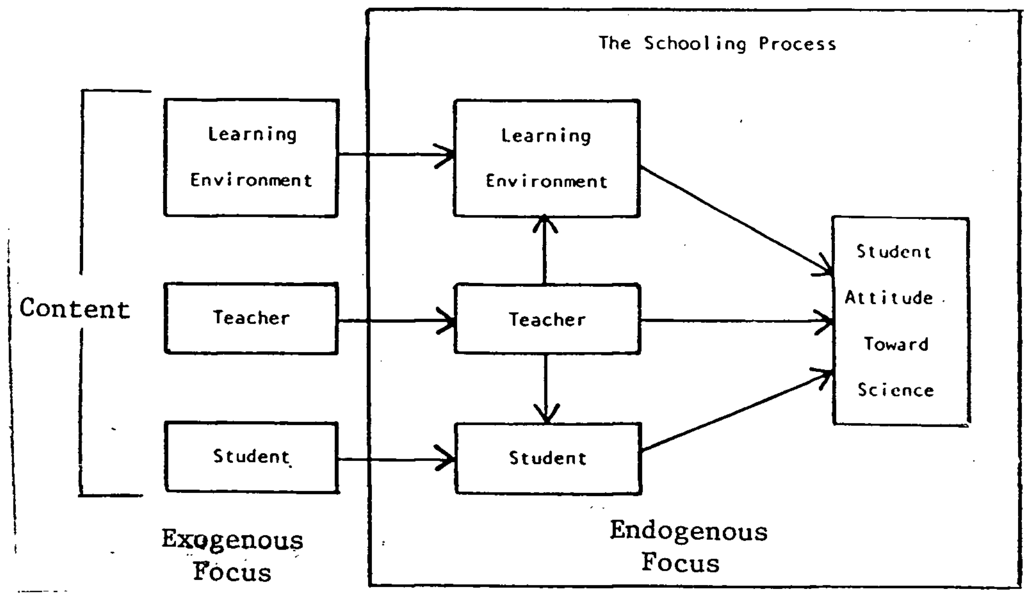
The Haladyna model was developed in response to "the perplexing body of research that sheds little light on what can be done, at the instructional program level to improve student attitudes toward the subject matter of science"

(Haladyna et al., 1982, p. 671). This model, which was based on their review of literature on variables which have been found to be related to student attitudes toward the subject science, suggests possible influences of these attitude. One of these influences was the classroom learning environment.

Figure 1, adapted from Haladyna et al. (1982,1983), illustrates the suggested relationships.

Figure 1

Relationships in the Haladyna Model



These relationships were also represented symbolically in the following expression:

$$Y=F(A,B,C)$$

where Y represents the criterion or dependent measure, attitudes toward the subject matter of science. B represents teacher variables, C represents learning environment variables, and A represents the student variables. While this expression is symbolic, it should imply to the reader that relationships are not simply linear, but may be complex, nonlinear, and involve interactions. (Haladyna et al., 1982)

In Figure 1, two major dimensions, which ultimately are related to student attitude toward the subject are considered, the content and the focus.

The content refers to three categories which interact in the learning process: the student, the teacher, and the learning environment. The focus refers to the location where the content categories are influenced. The focus, as illustrated in Figure 1, could either be exogenous, which includes variables or factors outside the influence of the school, or endogenous which includes variables or factors under the influence of the schooling process. Some examples of exogenous variables are: gender, socioeconomic status, intelligence. Some examples of student endogenous variables are: importance of science, student fatalism, and concern for grades. Examples of endogenous classroom learning environment are those described in the Learning Environment Inventory (Fraser, Anderson, & Walberg, 1982).

This study, because it was intended to provide relevant results for science teachers, considered only endogenous or within school learning environment variables which could possibly be manipulated by teachers in order to improve student attitudes toward Grade 10 science.

Arguments for the importance of the classroom learning environment as a variable which could be altered in order to improve student attitudes were presented by Haladyna et al. (1982) who viewed

> endogenous variables as critical in the development of attitudes, particularly those variables relating to the teacher and learning environment because these variables have potentially the greatest effect on attitudes, and teacher and learning environment variables may be changed to produce positive changes in attitudes. (p. 673)

Further Haladyna and Shaughnessy (1982) asserted that "the teacher is the primary change agent in affecting the learning environment, and that these two constructs, the teacher and the learning environment, work in concert to affect attitudes." (p. 551)

In summary the Haladyna model provided a very general perspective on the relationship between student attitude toward the subject science and the classroom learning environment. The Ajzen and Fishbein theory is described and analyzed in order to provide a more specific deliniation of how these student attitudes could be related to classroom learning environment variables.

2.1.2 OVERVIEW OF THE AJZEN AND FISHBEIN THEORY

The following analysis and description of the Ajzen and Fishbein (1980) theory is intended to provide an educational perspective on how attitude toward Grade 10 science was defined, acquired, changed, measured, and related to behavior. The background of the development and testing of this theory can be found in greater detail in Ajzen and Fishbein (1980), Fishbein and Ajzen (1975), and Fishbein (1967). It should be noted that although the theory is discussed in terms of a broader context of the relationships between belief, attitude, intention, and behavior, not all these relationships will be utilized in the abstraction of a theoretical notion of the association between student attitude toward the subject and classroom learning environment variables. The purpose of outlining the broader framework of the theory was in response to requests in the science education literature for theoretical foundations which would provide a better understanding of the meaning of attitude (Munby, 1983; Shrigley, 1983; & Zeidler, 1984).

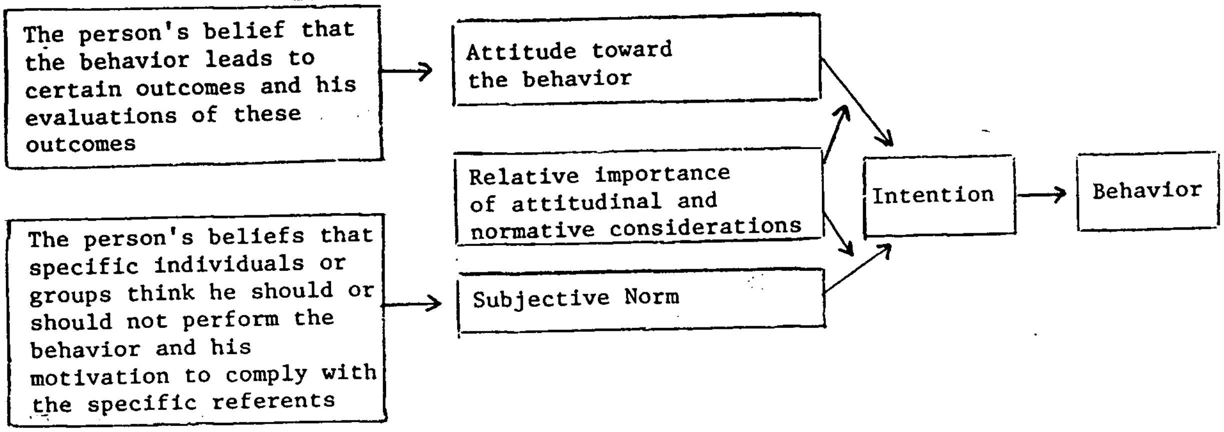
Summary of Theory

The ultimate goal of the theory, which Ajzen and Fishbein (1980) call the "theory of reasoned action", is to predict and understand an individual's behavior. Within the theory, an individual's attitude toward the behavior, ultimately is one of the underlying variables which influences their behavior. The theory is based on the assumption that human beings are usually quite rational and make systematic use of information available to them when a behavior is considered.

Figure 2 illustrates the key associations proposed in the theory. Each successive step from belief (4) to behavior (1) attempts to provide a more comprehensive account of the causes underlying the potential behavior of an individual. One of these causes, student personal attitudes toward behaviors related to the teaching/learning of Grade 10 science, was the focus of this study.

Figure 2

Overview of the Ajzen and Fishbein Theory



Note: Arrows indicate the direction of influence (from Ajzen & Fishbien, 1980)

1. In terms of predicting and understanding human behavior it is important to first identify the behaviors of interest. For example, one behavior related to the teaching/learning of Grade 10 science is reading the science text.

2. For this specific behavior an individual may or may not intend to read the text. The theory views intention to perform or not perform a behavior as an immediate determinant of whether or not the behavior is performed. Moreover, it assumes that, barring unforseen events, persons usually act in accordance with

their intentions.

3. In order to understand further the causes underlying the intention to behave, the next step is to identify the determinants of the intention. It proposes that there are two basic determinants of intention to behave, one personal and the other reflecting social influence.

a) The personal factor, is the individual's positive or negative evaluation of performing the behavior - their attitude toward performing the behavior. In our example of the intention to read the Grade 10 science text, an individual evaluates whether or not the consequences of this behavior will be favorable or unfavorable. If most of the consequences are viewed as favorable the resulting attitude toward the behavior is likely positive and the intention to perform the behavior is stronger.

b) The other determinant of intention, a social factor, is the individual's perception of the social pressures put on him/her to perform or not perform the behavior. This social factor is termed the subjective norm. In our example, if an individual perceives his/her friends as being very positive or favorable to reading the science text, then the individual's subjective norm is likely to be positive and his/her intention to read the text stronger. The strength of the personal attitudinal and subjective normative factors interact to determine the intention. For example, if an individual has a negative attitude toward reading the science text, he/she may still intend to read it because of the individual's perception that others (subjective norm) evaluate the behavior positively.

4. The theory also attempts to explain how attitudes and subjective norms are formed. According to the theory, attitudes and subjective norms are a function of an individual's beliefs about the outcomes of performing a behavior.

a) The individual's evaluation of the perceived outcomes of the behavior, if positive, would likely result in a positive attitude toward the behavior. These personal beliefs that underlie an individual's attitude toward the perceived outcome of the behavior are termed behavioral beliefs.

b) Another determing factor, related to the formation of individual's subjective norm, are termed normative beliefs. These beliefs entail the individual's perception of what their friends or important others believe the potential outcomes of the behavior are. This perception of what others believe provides the social pressure or motivation to comply with the beliefs of significant others.

In our example regarding the reading of the text, if the individual believes that reading the science text has negative consequences and they perceive significant others as believing the same, the resulting negative attitude and the social pressure not to read the text will likely result in the individual not reading the text.

It should be noted that within the theory there are other factors or variables which may be related to the behaviors of interest. These variables are called external variables. They include variables such as personality traits (e.g. need for achievement); and demographic factors (e.g. sex, social class). These variables are viewed as having an influence on the beliefs of a person or on the relative importance the person attaches to attitudinal and normative considerations. These variables, however, are viewed as affecting behavior to the extent they influence the intention to perform the behavior. The theory focuses on the attitudinal and normative determinants which are derived from an individual's personally and socially influenced beliefs about potential outcomes of performing a behavior.

The review of the Ajzen and Fishbein (1980) theory, up to this point, has included a statement of its basic assumptions, an outline of its essential propositions, and an indication of how it could apply in a science education context. Further specific information about the theory as it applies to this study is given in the following sections. This information includes: examples of behaviors related to the teaching and learning of Grade 10 science, an explanation of how attitude toward the subject is measured, a discussion on how student attitudes toward Grade 10 science could be changed, and a description of a theoretical notion of the association between student beliefs about the classroom learning environment and student attitude toward the subject science.

2.1.3 MEASURING STUDENT ATTITUDE TOWARD GRADE 10 SCIENCE

The Ajzen and Fishbein (1980) theory outlines a theoretical relationship between attitude toward a behavior and the behavior itself. Attitude toward the behavior is one of the intervening variables which is linked to the behavior. This study is concerned with behaviors related to the teaching and learning of Grade 10 science as a school subject. An attitude toward the subject was defined as a learned predisposition of an individual to evaluate, in a consistently favorable or unfavorable way, their performing of behaviors associated with the teaching/learning of the subject. The measure of attitude, based on this definition, was the Attitude Toward the Subject Science Scale (ATSSS).

Examples of some of these behaviors which were drawn from personal experiences, a review of pertinent literature, and consultations with science educators, are given below.

1. reading the Grade 10 science text at least once outside of classtime in a specified month of the school year
2. participating in a majority of the laboratory investigations done in class during that school year
3. voluntarily watching at least two science-technology related television programs within the school year (e.g. Nova)
4. keeping a complete well organized Grade 10 science notebook for the year

5. voluntarily reading at least one science-technology related article from a magazine or newspaper during a specific school month

According to the theory, the elements of specified behaviors must meet certain criteria. These criteria include: precise descriptions of the action, the target at which the action is directed, the context in which the action occurs and the time in which the action occurs. In this study, the action includes activities such as reading, watching, and asking. The context of these behaviors are within the scope of activities of a regular Grade 10 science program. The targets are specific activities that could occur within a typical junior high science classroom. The time involves, for the most part, the school year. This specification of criteria, from the previously defined behaviors, could be illustrated in the example of whether or not the student reads (action) the Grade 10 science text (target) outside of classtime (context) at least once in a specified month of the school year (time). The establishment of behavioral criteria is relevant in terms of the development of valid and reliable instrumentation to assess attitudes.

In order to assess an individual's attitude toward a specific behavior or set of behaviors related to an attitude object, the Ajzen and Fishbein (1980) theory relies upon standard attitude scaling procedures. The procedure advocated is the semantic differential scale (Osgood, Suci, and Tannenbaum, 1957). The development of the ATSSS, which is outlined in Section 3.33, was based upon this procedure.

In this procedure, the respondent is requested to evaluate each of the behaviors by checking a series of bipolar evaluative scales. For example:
My voluntarily reading (action) the Grade 10 science text book (target) outside of classtime (context) during this school month (time) is:

good.......:.....:.....:.....:.....:.....:.....: bad
(+3)(+2)(+1)(0)(-1)(-2)(-3)
foolish......:.....:......:......:.....:......:......: wise
(-3)(-2)(-1)(0)(+1)(+2)(+3)
pleasant......:......:.....:....:....:......:....:unpleasant
(+3)(+2)(+1)(0)(-1)(-2)(-3)

The response to each scale can be scored from (+3) to (-3). The sum of these scale scores is used as the attitude measure for that behavior. This differential method of attitude measurement, results in a single score which represents a given person's general evaluation or overall feeling of favorableness or unfavorableness toward behaviors related to the attitude object. The sum of the total set of scores for each of the behaviors represents the individual's attitude toward the attitude object.

2.1.4 CHANGING ATTITUDE AND BEHAVIOR

From the viewpoint of a science educator, it would be important to know, according to the theory, how student attitude and perhaps behavior could be altered.

According to the theory, changes in attitude and behavior are possible if beliefs about the consequences of performing the behavior could be changed. This possibilty implies that in order to influence behavior, we would have to expose our students to new information or learning which would produce changes in their beliefs about the outcomes of specific behaviors.

In the example of the behavior of text reading, teachers would have to design a situation which would cause students to believe reading the Grade 10 science text results in positive consequences such as improved science marks, better class discussions, and positive comments from significant others. This belief could result in a more positive attitude toward reading the science text and a more frequent reading of the text. Similarly, positive changes in attitude toward other behaviors related to the teaching/learning of Grade 10 Science could result in more positive student attitudes toward the subject. The key then is to influence as many salient beliefs about the consequences of behavior as possible in order to have a greater probability of influencing behavior.

According to Ajzen & Fishbein (1980), the nature of the information is of prime importance in the influence of student beliefs. They suggested that this information could be implicit or explicit. In an implicit way the source of the information conveys a message to the receiver. For example in a science education context, the teacher could ask students to follow a method of performing an experiment which was not done previously. This "new way" of doing things may change student beliefs about the subject science. In an explicit way the information could also attempt to change these beliefs about the consequences of performing specific behaviors. For example in a science education context, the teacher can communicate the positive consequences of reading the science text. Student knowledge of these consequences is thought to influence student beliefs about performing the behavior which in turn could influence student attitudes.

In terms of a practical situation, not all teachers may have the ability or desire to change student beliefs. It is believed, however, that most Grade 10 science teachers could attempt to change the beliefs of their students. Indeed, it is likely that teachers do attempt to change them. In this study, the identification of specific behaviors and the provision of a means to assess attitude might enable science educators to systematically teach for and evaluate their success in changing student attitudes toward the subject science.

The changing of student beliefs and attitudes, however, is not an easy task. The Ajzen and Fishbein theory of attitude formation and change was presented as one viewpoint about how this could be done.

2.1.5 USE OF THE AJZEN AND FISHBEIN THEORY IN THIS STUDY

The Ajzen and Fishbein (1980) theory involved three levels of explanation to outline the associations among beliefs, intentions, and behavior. At the most global level, a person's behavior was assumed to be determined by intention. At the next level, these intentions were themselves determined by the interactions of personal attitudes toward performing behaviors and social subjective norms. The third level explained how attitudes and subjective norms were based upon the beliefs about the consequences of performing the behavior and the normative expectations of relevant referents. In the final analysis, a person's behavior was explained by reference to their beliefs which were based on their information about the world. The position that behavior was ultimately determined by beliefs does not mean there was a direct link proposed between beliefs and behavior. Beliefs influenced personal attitudes and social subjective norms; these two components in turn influenced intentions to perform a behavior; and intentions influenced behavior. From a theoretical point of view, it was expected these hypothesized relations would hold, but for a variety of reasons they may not always do so in practice.

This study did not involve the total process of predicting and understanding behavior related to the teaching and learning of Grade 10 Science as a school subject. Instead one component of this understanding was investigated - student attitudes toward behaviors related to the teaching and learning of the subject science. A few reasons for only considering the attitudinal component included: the background of previous science education research, the call for a theoretical foundation for attitude research, and study feasibility. First, in terms of previous science education research, the abundance of studies which considered student attitudes toward science and the criticisms of these studies have already been noted. This study was an attempt at improving the quality of attitude research in science education. Second, there have also been criticisms which pointed to the lack of a theoretical foundation for attitude research in science education. Because of these criticisms a theoretical position was described and applied in this study. Third, the researcher had to be concerned with the limitations of data base availability, and cost. He therefore, chose to focus on what was feasible.

Reasons for Selecting the Ajzen and Fishbein Attitude Theory

McGuire (1985), in a review of attitude and attitude change literature, noted that most research in social psychology has been concerned with attitude. Rajecki (1982) believed that the major reason for this interest in attitude was that

> There is a pervasive sense in the layperson and scientist alike that our behavior is influenced by our attitudes, whereby attitude is seen as the cause and behavior is seen as the effect (p. 3).

Moreover, he went on to claim that the study of attitudes is an attempt to increase our understanding of human behavior. Fisher (1982), in his analysis of attitude research supported Rajecki in his assertion that " Attitude is an important concept that holds a great deal of potential for generalizing and predicting social behavior" (p. 46). This potential, however, has not always been realized (Ajzen & Fishbein, 1980; McGuire, 1985; & Rajecki, 1982). For example McGuire (1985) found that empirical evidence to support an attitude-behavior connection has been lacking. He concluded that

> My own dismal line is that only within quite limited circumstances do attitudes account for more than 10 percent of behavioral variance except when they are correlated not with behavior per se but with self-reports of intention to behave. (p. 252)

The literature reviewed in the realm of attitude research revealed differing views of how attitudes are formed and changed and related to behavior. (Cooper & Croyle, 1984; Cialdini, Petty, & Cacioppo, 1981; McGuire, 1985; & Suedfeld, 1971). Suedfeld (1971) noted that

> It is not always possible to compare and contrast these theories as black and white. Moreover, there are many similarities and overlaps in terms of the inferences which can be drawn from them. There are sometimes similarities in the basic approach and underlying assumptions and often differences in the questions asked, scope of the theory, and the language used to describe them (p. 2).

Most attitude theories, however, originate from two major schools of thought. These schools, the behavioral and cognitive consistency, have also shaped research and theory in other areas of concern in social psychology. The behavioral school emphasizes stimulus-response associations while the cognitive consistency school is based on field theories.

The behavioral approach, which the Ajzen and Fishbein view is closely associated to, is concerned with the process whereby a given response becomes associated with (conditioned to) a given stimulus. This learning of an association is explained in terms of two conditioning paradigms - classical and operant. Suedfeld (1971) noted that these theories

> emphasize that attitudes have adaptive significance to the people who hold them. They may be based on past reinforcements or the prospect of future reinforcements... Also, a stimulus similar to one that was

present in a former favorable stimulus-attitude action chain will tend to evoke the same response through the process of generalization. (p. 29)

Theories of cognitive consistency purport that each of us has a tendency to look for consistency among our beliefs, cognitions, and behaviors. We may seek this consistency among the components of attitude (cognitive, affective, conative) or between these components and information we acquire about our environment. Malec (1971) noted that consistency theories are direct descendants of gestalt and field theory; both of which emphasize the notions of field and organization. Field refers to coexisting and interdependent factors within an individual's social experiences (e.g. family, peer group, school). These factors with their perceived properties, interact as a system in a social context. The concept of organization refers to the assumption that individuals attempt to achieve some kind of psychological order in their field. In other words, the individual in social contexts, attempts to cognitively achieve some order within his/her field.

Given these two major views of attitude formation and change, a brief rationalization for the selection of the Ajzen and Fishbien view follows. Ajzen and Fishbein (1980) noted the difficulties associated with the prediction of behavior of individuals based on their attitude toward an object. Moreover, they also noted the literature which continued to assume there is a close link between attitude and behavior and that attitude is a complex system consisting of an individual's beliefs about the object, their feelings toward the object, and their behavioral tendencies with respect to the object. Based on their analysis of attitude research, they concluded that "the multicomponent view of attitude can not provide an adequate explanation of the low attitude-behavior relation" (p. 21). They also noted that this problem of incongruency received little attention in the attitude literature with a greater emphasis being put on descriptive attitude surveys and experimental designs to determine how attitudes were formed and changed.

The Ajzen and Fishbein theory attempts to provide a better understanding of the association between attitude and behavior. In their view attitude is not the only factor that determines behavior. Morover, attitude, the evaluation of a psychological object or behavior, is viewed as being distinct from beliefs, intentions, and behavior. In short, they propose that an appropriate measure of attitude, that is one that measures attitude toward performing behaviors, could provide a better means by which to understand and predict behavior. One reason this theory was selected was that it provided a perspective which is relevant to what teachers attempt to do in their daily interactions with students - that is to promote positive behaviors related to the teaching and learning of their subject. Using this theory, the role of attitude as related to these behaviors is clearly outlined. In addition this theory has also been suggested, in the science education literature, as one which may be useful in terms of providing a theoretical foundation for investigations into student attitudes in science education research (Hartman, 1972; Shrigley, 1983; & Zeidler, 1984).

2.1.6 THEORETICAL NOTION OF THE ASSOCIATION BETWEEN CLASSROOM LEARNING ENVIRONMENT VARIABLES AND STUDENT ATTITUDE

A theoretical notion of how positive attitudes toward the subject science can be achieved through the manipulation of classroom learning environment variables is summarized in this section. This summary is based on an interpretation of the theory (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975; & Fishbein, 1967). The essentials of this notion are illustrated in Figure 3.

Figure 3

Relationship Between Classroom Learning Environment and Student Attitude Toward Grade 10 Science

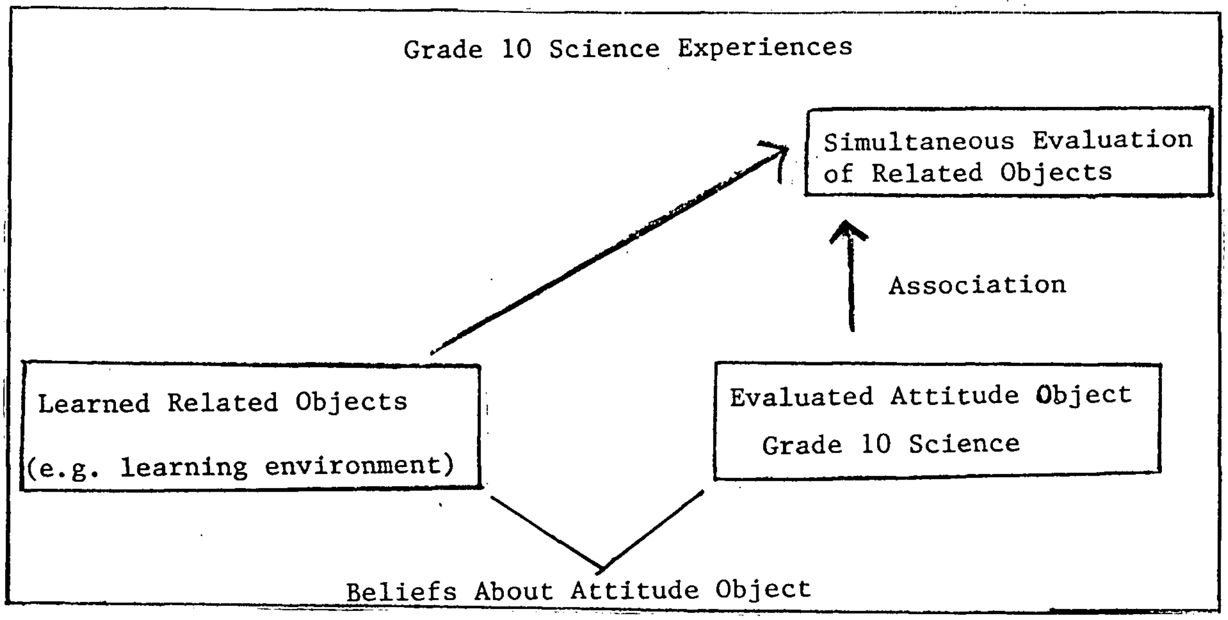


Figure 3 suggests that Grade 10 science experiences allow students to learn about objects related to the subject. These objects could include classroom learning environment variables such as the organization of the class and speed at which class material is covered. Further, as students learn about these related objects they also simultaneously evaluate them. These evaluations of related objects become associated with the attitude object through the credibility of a belief statement about the attitude object.

An explanation for how these associations come about is given using a combination of classical conditioning and mediation. Figure 4 illustrates in further detail this explanation.

Figure 4

Association Between Attitude and Learning Environment

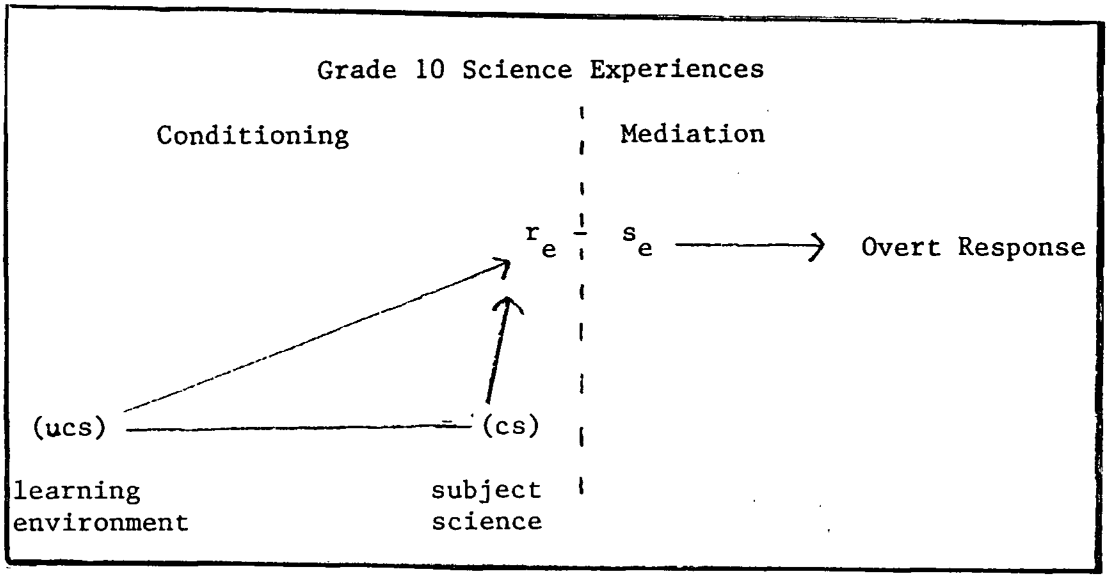


Figure 4 suggests that students, in learning about Grade 10 science, are exposed to unconditioned stimuli such as learning environment variables. Students, in learning about the environment also simultaneously implicitly evaluate it (evaluative response). Through repeated exposure with the environment, the subject science becomes a conditioned stimulus whereby it evokes a similar evaluative response as the unconditioned stimulus. Further, using an analagous situation of conditioning with animals, the conditioned stimulus (bell), produces a similar response (salvation), as the unconditioned stimulus (meat powder).

The learning and evaluation of related objects are part of the conditioning process whereby an attitude toward the subject is acquired. Fishbein (1967) viewed the evaluation of attitude object (performing behaviors related to the object) as the individual's attitude. He asserted that "attitude is a learned implicit response that varies in intensity and tends to mediate or guide an individuals more overt evaluative responses to an attitude object or concept" (p. 389). The key notion here is that attitudes are mediated implicitly by students. The mechanism of this mediation is partially explained by using anticipatory goal response theory as proposed by Hull (1943) and further developed by Doob (1947). Briefly the key notion utilized from this theory is that the evaluative response (r..) acts as a stimulus (s..) which guides an overt attitudinal response (e.g. to an attitudinal scale). Fishbein further argued that one could elicit an overt attitudinal response toward an attitude object based on the presentation of a belief statement about the attitude object. The strength of the evaluative response depends on how strongly the statement or assertion is believed and how strongly it is evaluated. In summary then, the association between the subject science and classroom learning environment variables is a probabilistic one, based on the principles of classical conditioning and implicit mediation of responses.

Given this viewpoint about the relationship between classroom learning environment variables and student attitude toward the subject science, it was reasoned that if one could change student evaluations about the classroom learning environment or change the family of related objects they would be able to change student attitudes toward the subject science. This notion of how attitudes are acquired and changed as related to the classroom learning environment was applied in the design of a teaching/learning strategy to promote more positive attitudes.

2.1.7 COMPATABILITY OF HALADYNA MODEL AND AJZEN AND FISHBEIN THEORY

The compatability of the Ajzen and Fishbein (1980) theory of attitude acquisition, change, and measurement with the Haladyna et al. (1982) model of determinants of attitude toward the subject science could be illustrated by an analysis of a science classroom situation. For example, within the science schooling process, learning about the subject science occurs within the classroom learning environment. According to Ajzen and Fishbein (1980), students evaluate this learning environment. Positive evaluations of the learning environment are eventually associated with positive evaluations of the subject.

According to Haladyna et al. (1982), the teacher controlled classroom learning environment, with variables such as how well the class is organized or how quickly material is covered, influences student attitudes toward the subject science.

The connection between the Haladyna et al. (1982) model of determinants of student attitude toward the subject science and the Ajzen and Fishbein (1980) theory of how attitude is acquired and changed is that Haladyna identified some of the variables which could influence student attitude while Fishbein explained how these variables could be associated to the subject. Some of these variables may influence student attitudes to a greater extent than others. Two intentions of this study were to determine which variables had the greatest influence and to design a strategy for how these variables could be manipulated in order to improve student attitudes.

2.2 REVIEW OF RELATED RESEARCH

2.2.1 OVERVIEW OF RESEARCH WHICH CONSIDERED STUDENT ATTITUDES IN SCIENCE EDUCATION

There has been considerable research into student attitudes toward science at all education levels. Four major reviews have highlighted the methods, results and problems in this area of research. Ormerod and Duckworth (1975) have provided the most extensive review of the results and implications of over 500 studies. Gardner (1975a) examined this general area, with evaluations of the results and instrumentations used. Munby (1980) highlighted the problems of assessment and instrumentation through an evaluation of over 50 attitude instruments. Schibeci (1984) updated attitude toward science research in an extensive review which encompassed over 200 studies. This review highlighted some of general conclusions and issues within this research area. Articles written by Schibeci (1983), Haladyna et al. (1982), Shrigley (1983), and Aiken and Aiken (1969) also provided a general overview of research in the area.

Prior to an examination of some of the findings, conclusions, and problems in this research there will be a clarification of the meanings which have been associated with the concepts of science, scientific attitudes, and attitudes toward science. This clarification was provided because of confusion in the meanings that caused some difficulty in the interpretation of previous research findings (Schibeci, 1984).

2.2.2 MEANING OF THE CONCEPT SCIENCE IN ATTITUDE TOWARD SCIENCE RESEARCH

The concept "science", to which attitudes have been associated, appeared to have multi-dimensional meanings (Gardner, 1975a; Koballa, 1983; Pearl, 1973;

& Santiesteban, 1976). Munby (1980), in a review of attitude assessments and instrumentation, found five major meanings. These meanings considered attitudes toward: science instruction, science careers, science itself, specific science issues, and scientific attitudes. Klopfer (1971), in a major classification of 267 attitude aims from 117 sources, established six meanings for science. These were: manifestation of favorable attitudes toward science and scientists, acceptance of scientific inquiry as a way of thought, adoption of scientific attitudes, enjoyment of science learning experiences, development of interests in science and science related activities, and development of interest in pursuing a career in science. Fraser (1977) modified Klopfer's scheme subdividing the attitudes toward science and scientists category. The majority of the attitude toward science research reviewed incorporated one or more of these meanings. In this study one aspect of science, attitudes toward science as a school subject, was investigated.

2.2.3 ATTITUDES TOWARD SCIENCE COMPARED TO SCIENTIFIC ATTITUDES

In terms of attitudinal aims or objectives for science education programs two general categories have been established (Gardner, 1975a; Gauld & Hukins, 1980; & Schibeci, 1983,1984). These categories included both the promotion of positive student "attitudes toward science" and "scientific attitudes." Different definitions have been given to these categories (Aiken & Aiken, 1969; Gardner, 1975a; Pearl, 1973; Fraser, 1977; Schibeci, 1984; Shrigley, 1983; & Zieldler, 1984). However, they have also been confused or combined in assessments of student attitudes (Gauld & Hukins, 1980; & Koballa, 1983). An excellent example of this confusion was illustrated by the critical analysis of the widely used Scientific Attitude Inventory (Moore & Sutman, 1970) by Munby (1980,1983) and Nagy (1978) which revealed inconsistencies in the attitudinal constructs supposedly being measured. These constructs were found to be of a cognitive nature in terms of what students knew about science rather than what their attitudes toward science were. Some examples of meanings associated with both scientific attitudes and attitudes toward science are presented below.

Scientific Attitudes

Scientific attitudes have generally been perceived as desired attributes of scientists in professional work and hence their acquisiton was deemed as an appropriate objective for science curricula (Munby, 1980). Examples of these attributes are: open mindedness, curiosity, honesty, skepticism, critical thought, rationality, and objectivity. Some science educators have developed lists of desirable attitudinal attributes (Billeh & Zakhariades, 1975; Diederich, 1967; Kozlow & Nay, 1976; & Vitrogan, 1967). Doran (1980), who reviewed some attitudinal lists and other literature, concluded that there is no one standard list, however, many common attitudinal attributes were found among them. More recently, there has been some criticism of having the attainment of these attributes, which may not describe the characteristics of scientists at work, (Gauld, 1982; & Schibeci, 1983,1984), as appropriate objectives for science education programs.

Specific definitions have been used to describe scientific attitudes. Some examples found were : "an adherance to knowledge of the scientific method" (Aiken & Aiken, 1969, p. 296), "the adoption of a particular approach to solving problems, to assessing ideas and information or to making decisions" (Gauld, 1982, p. 110), and "those habits of mind... typically meant to characterize the mental processes of a scientist at work" (Munby, 1983, p. 142). In general, scientific attitudes were viewed as desirable traits, characteristics, or attributes of scientists at work. A review of research in the area of scientific attitudes has been provided by Gauld and Hukins (1980). In this review, the nature of scientific attitudes, findings of previous studies, and a discussion about the appropriateness of these attitudes as objectives were presented.

Attitudes Toward Science

The concept of an attitude toward science has not had as clear a meaning in science education research as scientific attitudes. This concept has had diverse meanings and uses in attitudinal research. Some of the meanings have included, for example, "feelings, opinions, beliefs in and about, and appreciations which individuals have formed as a result of interacting directly and indirectly with the various aspects of the scientific enterprise" (Hasan & Billeh, 1975, p. 247). Gardner (1975a) viewed the meaning as "emotional reactions of students toward science" (p. 2). Dutton and Stephens (1963) viewed these attitudes as "how an individual feels about science" (p. 43). Munby (1980) in an extensive review of attitude instruments found most attitude assessments involved an individual's "feelings, beliefs, likes" (p. 268) toward an attitudinal object in the field of science.

The unclear meaning of what an attitude toward science represented has created problems in terms of coordinating and comparing attitude toward science research. This research has been plagued with inconsistent and contradictory findings (Aiken & Aiken, 1969; Gardner, 1975a; Mallinson, 1977, Munby, 1980; Peterson & Carlson, 1979 ; & Schibeci, 1984). Reviews of the meaning of the attitude concept by Schibeci (1983), who provided a perspective on problems in attitude definition, and Shrigley (1983), who examined possible alternatives for clarifying the attitude concept in science education research, have made significant contributions in terms of suggestions for future research. In this study the meaning of attitude toward science was described according to a theoretical position presented by Ajzen and Fishbein (1980).

2.2.4 RESULTS OF ATTITUDE TOWARD SCIENCE RESEARCH

Studies which investigated student attitudes toward science have often been justified by the prevalence and expressed importance of attitudinal goals or objectives for science education programs. These studies commonly involved: the assessment of student attitudes in relation to these objectives; the difference in attitude as a result of curriculum or teaching method; the association of attitude to other variables of interest; or the development of attitude assessment instruments. Some of the significant findings, conclusions, and issues surrounding this research are discussed in this section.

Variables Investigated

The most often investigated variables which have been hypothesized to be related to attitude were: student achievement, specific teaching method, special curriculums or materials, type of science (e.g. physical or biological), student age or grade, student perceived difficulty of science, the influence of student personal variables (e.g. gender, I.Q., socioeconomic status), teacher characteristics (e.g. attitude, experience), and the classroom learning environment. Less common were studies which considered the effect of home and outside forces such as the media, religious, and cultural background. An extensive categorization of studies by variable has been given by Omerod and Duckworth (1975) and Gardner (1975a). Schibeci (1984) has also categorized attitude toward science research by variable. These categories included: personality, sex, structural or demographic, school, curriculum, and instructional.

Research into variables which may influence student attitudes toward science has not produced many conclusive results. There have been a few generalizations, however, which have been accepted for the most part. It should also be noted that there were varying degrees of conflict in the degree of agreement upon these generalizations. Santiesteban (1976), Gardner (1975a) and

Munby (1980) have suggested, caution be used in the interpretation of findings which have resulted from attitudinal research in science education. There has been, however, some evidence to support the following variables as influences of student attitude toward science: gender, achievement, the perceived difficulty of science, the different sciences, student grade level, and the teacher influenced classroom learning environment.

Gender, the most frequently considered variable (Haladyna & Shaughnessy, 1982), has been reported to be related to student attitudes toward science (Aiken & Aiken, 1969; Comber & Keeves, 1973; Fraser, 1978a; Gardner, 1975a; Haertel et al., 1981; & Ormerod & Duckworth, 1975). Males have been reported to have more positive attitudes than females (Ato & Wilkinson, 1982; Kuhn, 1979; Lowery et al., 1980; & Sjoberg, 1983). Gardner (1975a) asserted that "sex is probably the single most important variable related to pupils' attitudes to science" (p. 22). Furthermore, Schibeci (1984) also concluded "of the myriad of variables which are possible influences of attitudes, sex has generally been shown to be a consistent influence" (p. 33). However, not all studies have reported statistically significant sex differences in attitude (Ayers & Price, 1975; Hamilton, 1982; Moyer, 1977; & Wareing, 1982). Haladyna and Shaughnessy (1982) in a meta-analysis found sex predicted only 3.2% of the variance in attitude toward the subject science. The results of the British Columbia Science Assessment (1982), however, were of particular significance because no statistically significant differences in attitude toward the subject science in grades 8, 10, and 12 were found.

In terms of research which considered gender attitudinal differences, there has been some consideration of the important question of why there may be differences. Hadden and Johnstone (1982), in a study of elementary school students found that boys may be more aware of the value of science for its career potential than girls. Another factor which may cause differences is the science discipline involved. Ormerod and Duckworth (1975) and Gardner (1975a) concluded that biological and physical sciences evoke different attitudes. Hodson and Freeman (1983) found that, in primary school, the content of the science materials was more male oriented. Erickson and Erickson (1984), in their analysis of gender achievement differences, provided some insights into possible sociological causes for these differences. These causes may also apply to attitudes. This question of why there may be sex differences in attitude, if indeed there are differences, and what could be done to eliminate these differences, is an interesting one for further investigation.

Another relationship often investigated in attitude toward science research was that of student achievement to attitude. Hough and Piper (1982) asserted that "the relationship of attitude to cognitive development and achievement has been assumed to be a logical and invevitable connection" (p. 33). A few researchers have found significant relationships (Boulanger, 1981; Eisenhardt, 1977; Hough & Piper, 1982; Kahle, 1982; Simpson, 1977; & Simpson & Wasik, 1978). Of particular significance was the two and one half year study of Eisenhardt (1977) which involved over 70,000 American students from grade six to twelve. Based on this study, he concluded that achievement influenced attitudes. It should be noted that not all researchers agreed upon whether or not attitudes influence achievement or vice versa. Fraser (1982), for example asserted that "science teachers wishing to improve their students cognitive achievement would be well advised to attack the problem directly rather than by attempting to enhance achievement by first changing students' attitudes to science" (p. 558).

The assumption, and in certain cases the research findings, have not always supported a strong attitude-achievement connection, but rather a low positive correlation (Fraser, 1982; Gardner, 1975a; Novick & Duvdvani, 1976;

Napier & Riley, 1985; Schibeci, 1984; & Steinkamp & Maehr, 1983). Of particular significance was the finding of Willson (1983), who in a meta-analysis of attitude toward science studies, found 75% of correlational coefficients to be below 0.30. Schibeci (1984) concluded that cognitive and affective variables are linked, however, both the direction and strength of this link were not clear.

The perceived difficulty of science was viewed by Ormerod and Duckworth (1975), in their extensive review, as "one of the two strongest variables related to attitudes to science of students" (p. 10). This difficulty was associated to declining science enrollments and the aversion of girls for physics. Orpwood (1976), in a review of Ormerod's publication, believed that the issue of why science was viewed as difficult in relation to curriculum decisions needed further analysis.

There have been quite a few studies which have reported a decline in student attitudes with increasing grade level (Ayers & Price, 1975; & Johnson, 1981). Hadden and Johnstone (1983) reported that girls' attitudes declined more than boys with increasing grades. Malone and Fleming (1983), based on a meta-analysis, found males had more positive attitudes in elementary and senior secondary years while females had more positive attitudes in the middle school years. This finding of fluctuations might lead to the question of whether changes in attitudes toward the subject science differ in ways different than any other school subject. It should also be noted that not all studies have reported a decline in attitude with increasing grade (Aiken, 1979; Hobbs & Erickson, 1980; & Power, 1981).

Student perceptions or beliefs about various aspects of the science classroom learning environment have been related to student attitude toward science. Classes with favorable learning environments have been associated with more favorable attitudes (Fraser, 1978b; Haladyna et al., 1982; Lawrenz, 1976a).

One focus of this study was to determine which specific teacher controllable variables were related to student attitude toward Grade 10 science.

Investigations which involved other variables previously mentioned such as specific materials or methods, teacher variables, socioeconomic status, intelligence, location, and family mobility, for the most part, have not produced significant associations. However the wide range of studies and the diverse instrumentation used made it difficult to compare the effects of these variables. For example, in the area of instructional and curriculum manipulations there have been numerous researchers who have found that these manipulations influenced student attitudes. However, as Schibeci (1984) asserted "the strength of this influence is difficult to determine from the studies reviewed" (p. 42).

2.2.5 SUGGESTED IMPROVEMENTS IN ATTITUDE TOWARD SCIENCE RESEARCH

Based on the lack of integrative findings and conflicting results, critical comments have been made about the state of science education attitudinal research (Haladyna et al., 1982; Lowery, 1980; Mallinson, 1977; Peterson & Carlson, 1979; Russell, 1981; & Schibeci, 1984). Assertions by Mallinson (1977) who stated that "frustration comes from the inconclusive, and in many cases contradictory findings of the studies"(p. 167) and Peterson and Carlson (1979) who concluded "attitude research is chaotic" (p. 500), and Schibeci (1984) who found it "disappointing that the set of conclusions which can be drawn from such a large body of literature is so limited" (p. 46), typified some of the general criticisms of the research results. There have been both general and specific problems or concerns identified in the realm of attitude to science research. Some of these problems and suggestions for improvements will now be reviewed.

<u>General Problems and Concerns</u>

1) The overabundance of small scale studies with different designs and instrumentation (Klopfer, 1983; Peterson & Carlson, 1979; & Ormerod & Duckworth, 1975). Related to this concern has been the expressed need for the establishment of better communications between attitude researchers, through such mechanisms as special journals or instrument catalogs (Munby, 1980; Klopfer, 1983; Pearl, 1973; & Wilson, 1981).

2) The need for a more critical evaluation of studies (Gardner, 1975a,b; Moyer, 1975; Klopfer, 1983; Munby, 1980; Schibeci, 1984; Simpson, Shrum, & Renz, 1972,1976; Quinn, 1976). Based on this review, it appeared there were numerous published science education articles which critically analyzed previous attitudinal research (Gardner, 1975a ; Haladyna et al., 1982 ; Munby, 1980,1983; & Schibeci, 1984).

3) The need for improvement of research methods in terms of: a more careful variable selection (Anderson, 1971; & Haladyna & Shaughnessy, 1982), more innovative designs (Doran et al., 1974; Eggen, 1978; Gardner, 1975a; Lutz & Ramsey, 1974; Peterson & Carlson, 1979; & Russell & Hollander, 1975), and the establishment of clear theoretical foundations for the research design (Messick, 1975; Koballa & Crawley, 1985 ; Munby et al., 1976; Shrigley, 1983; & Steiner, 1980).

4) The general difficulty associated with quantifying a complex construct called attitude (Eggen, 1978; Gabel et al., 1977; Leece & Mathews, 1974; Ost & White, 1979; & Santiesteban, 1976).

Measurement Problems

A majority of the problems noted were concerned with shortcomings of instruments used to collect attitudinal data (Anderson & Herrera, 1976; Champlin, 1970; Comber & Keeves, 1973; Gabel et al., 1978; Gardner, 1975a,b; Pearl, 1973 ; Peterson & Carlson, 1979; Schibeci, 1983, 1984; Townbridge, 1979; Ost & White, 1979; & Wilson, 1981). Pearl (1973), for example noted that "the literature reveals one consistent theme- the total inadequacy of science attitude measurement" (p. 273). Further, Munby (1980), in an analysis of 50 attitude to science instruments, asserted "there are grounds for viewing the affective outcomes of science education with misgiving simply because there seems little to be said of the instruments to enlist our confidence in their use" (p. 273). Many of the specific shortcomings of instrumentation noted and elaborated on by others, have been summarized by Gardner (1975a); Haladyna et al. (1982) and Schibeci (1984). Some of these instrumentation shortcomings were concerned with:

1) The need for the specification of a theoretical construct to underlie the instrument (Messick, 1975; Munby, 1983; Munby et al., 1976; Nagy, 1978; Shrigley, 1983; & Zeidler, 1984) and the clear definition of the construct to be measured (Aiken & Aiken, 1969; Butts, 1983; Haladyna & Shaughnessy, 1982; Koballa, 1983; Munby, 1980; & Schibeci, 1984).

2) The need for the verification or establishment of reliability and validity instruments (Bratt, 1984; Butts, 1983; Champlin, 1970; Gabel et al., 1978; Hofstein et al., 1979; Munby, 1980; Pearl, 1973; & Schibeci, 1983,1984). Specific suggestions given for the improvement of reliability and validity were: the use of test-retest reliabilities (Munby, 1980), the use of factor and cluster analysis to empirically validate subscales (Munby, 1980; & Nagy, 1978), separate scores for

conceptually distinct aims (Fraser, 1978a; & Pearl, 1973), more careful wording and testing of items (Butts, 1983; & Shrigley, 1983), and the preliminary trial of the instrument on the population for whom the use is intended (Butts, 1983). It should be noted that most of these suggestions were considered in this study.

It has been suggested by Klopfer (1983) and Mayer and Richmond (1982) that some of the problems with instrumentation might not be an exclusive concern of attitude researchers, but rather a concern of educational researchers in general.

The message has been clear, that in general the results of attitudinal studies have been found to be lacking in certain respects. These criticisms were in two general streams, the questionable quality of the instrumentation and the lack of a theoretical foundation as a basis for the research (Munby et al., 1976). However, the importance of the promotion of positive attitudes and the support for continued attitudinal research has also been evident (Leece & Mathews, 1976; Moyer, 1975; Peterson & Carlson, 1979; Shrigley, 1983; & Simpson et al., 1976).

The questionable quality of some attitude toward the subject science suggested questions such as: What do we really know about student attitudes toward science?, and How can we find out more about student attitudes as related to expected behaviors?, and What directions should future research take? This study attempted to gain further knowledge in order to answer these questions.

2.2.6 OVERVIEW OF CLASSROOM LEARNING ENVIRONMENT RESEARCH

Educational research included investigations of the classroom learning environment or social climate for learning. In terms of providing an overview of this research other articles provided a review of the major types of studies, techniques of investigation, results, and issues in the area. Some of the more substantive reviews included: textbooks on educational environments edited by Walberg (1974,1979); a special edition of Studies in Educational Evaluation edited by Fraser (1980); a comprehensive literature review of published research done by Fraser and Walberg (1981); a meta-analysis of research done by Haertal et al. (1980); a text on social research by Moos (1979); a review and analysis of environmental research up to 1973 by Randhawa and Fu (1973); an overview of research which utilized the LEI (Fraser, Anderson, & Walberg, 1982), and finally a review of the measure used to study classroom climate done by Chavez (1984). Some of the findings of this research in terms of the meaning of learning environment, types of studies done, and issues are discussed below.

Meaning of Classroom Learning Environment

The classroom learning environment variables under investigation in this study were operationally defined by 15 variables in the Learning Environment Inventory (Fraser, Anderson, & Walberg, 1982). According to the developers of this instrument, classroom learning environment was defined as the "interpersonal relationships among pupils, relationships between pupils and both the subject studied and method of learning, and finally, pupils' perceptions of the structural characteristics of the class" (p. 2). This definition appeared to be consistent with other definitions of learning environment presented in the literature (Haukoss & Penick, 1983; Hofstein, Gluzman, Ben-zvi, & Samuel, 1980 ; & Trickett & Moos, 1973) and hence was selected as the operational definition for classroom learning environment in this study. Moreover, the LEI (Fraser, Anderson, & Walberg, 1982) was selected as a measure of learning environment variables because of its extensive development, testing, and usage at the high school level from 1968 to 1984.

It should be noted that there have been other classroom learning environment variables defined in the literature, the most prevalent, next to those in the LEI, were those in the Classroom Environment Scale (Moos & Trickett, 1974). One limitation in this study was that only teacher controllable variables from the LEI were investigated. Taiguri (1968) noted, however, that in the selection of variables for school climate research; "In principle just about everything may make a difference to behavior, yet to include everything is not useful" (p. 14). The selection of certain variables is a limitation of not only this study, but perhaps all educational research.

Types of Studies

The strongest tradition in prior learning environment research, especially that which involved the LEI, first to third versions, has been concerned with the predictability of student cognitive, affective, and behavioral outcomes from student perceptions of the classroom. The previously mentioned reviews of the area provided an account and evidence for consistent and strong relationships between student perceptions of the classroom learning environment and student learning outcome variance. Fraser (1980) commented on these reviews. He asserted that

> In fact, a large number of studies conducted in numerous countries has provided consistent and strong support for the incremental predictive validity of students' perceptions in accounting for appreciable amounts of learning outcome variance, often beyond that attributable to student entry characteristics such as pretest performance and general ability. (p. 221)

One must be cautious, however, in the interpretation of this evidence. Haertal et al. (1981) suggested there is no proven causal relation between student perceptions of classroom learning environments and student learning.

Given the number of classroom learning environment studies, one might question the need for further studies. Schibeci (1984) noted, however, that relative to the total quantity of research done, not many studies considered the relationship between student attitudes toward the subject science to learning environmental variables. He also noted that further research into the relationship was desirable and should prove fruitful. This study attempts to provide additional information on this relationship.

The other major direction of learning environment research has involved the use of student perceptions of the learning environment as criterion variables. In particular, this research has been utilized in investigations of curricular effectiveness (Fraser, 1979; Walberg, 1968; & Walberg & Ahlgren, 1970). Walberg and Haertal (1980), in their review of learning environment research, concluded that

> Researchers are learning increasingly that valid and useful differences among educational treatments are often reflected first and most strongly in changes in student perceptions of their learning environment. Later, and in moderated form, these changes also show up in terms of student learning. (p. 232)

There have also been other types of criterion variable research where learning environment variables were considered as outcomes. Some of this research has involved the explorations of: grade level differences in learning environment (Welch, 1979); the differences between science learning environment compared to other subjects (Anderson, 1971; Steele, House, & Kerins, 1971); differences in environment in different types of schools (Randhawa & Fu, 1973; & Randhawa & Michayluk, 1975) ; differences in special classrooms (Hofstein et al., 1980); and the relationships between teacher personality and classroom environment (Gardner, 1976; & Walberg, 1968).

Techniques of Investigation

Given that classroom learning environment research has involved mostly predictive and criterion studies, there have been different techniques used in these studies. These differences, for the most part, were based upon whose perception of the environment was considered and the methods by which data was collected. The three main sources of perception were from that of observers, teachers, and most frequently students.

In terms of the ways in which data was collected Fraser and Walberg (1981) identified three major ways. First, and least common, were case study approaches such as outlined by Stake and Easley (1978). Second, was a category called interaction analysis which involved observers coding or recording class activities. According to Power (1977), who reviewed classroom interaction research, this coding has been done through informal or formal observation schedules. Third, was the approach of using teacher and student self reported perceptions or beliefs about the classroom. This approach was most frequently done through the use of rating scales such as the LEI or CES.

Issues

With regard to the provision of an overall feeling for the issues involved in learning environment research, there were two articles which were worthy of note - the review of classroom interaction studies by Power (1977), and the analysis of schools social climate research by Anderson (1982). Some of the pertinent issues raised in these and other articles are discussed below.

Power (1977), explored different possible paradigms which could guide the science classroom researcher. Within this exploration, a number of issues were raised. One major issue alluded to the lack of concurrent validity of student ratings with respect to observed classroom behavior (Tisher & Power, 1976). Further investigation needs to be done in this area of concurrent validity. This issue is relevant to this study in that no data was collected to determine if student self reported perceptions of the classroom learning environment were congruent with what was observed.

Power (1977) also expressed some concerns about the observation systems which have been developed to monitor classroom interactions and behavior. First, he suggested that there was a lack of an explicit base for many observational categories established, and consequently the constructs of the instruments were ill defined. Second, he also doubted the value of low inference data gained from the observations because little information was provided about the social and physical context and degree of strength of the observations. For example, one teachers "good" response may mean more to a class than another teachers.

The value of high inference student rating scales versus low inference observational information was discussed by other classroom researchers. The majority appeared to be more supportive of high inference methods. For example, Randhawa and Fu (1973) and Welch (1973) believed observers in the room altered student behaviors, while Walberg and Haertal (1980) found discrimination in behavior lacking in observational systems. Moreover, Fraser (1981a) concluded that information from observation systems seemed to provide abstract and nebulous data. On the other hand, numerous researchers have noted that student perceptions provided useful accurate information about classroom life (Cooper & Cooper, 1976; Cooper & Petrosky, 1974; & Lawrenz, 1976b).

Another pertinent issue found in the literature was that of the usefulness of learning environment research. There have been suggestions that the analysis of classroom learning environments were valuable to teachers in terms of teacher self analysis (DeYong, 1977; & Sibergeld, Koening, & Manderscheid, 1975) and the better attainment of the stated objectives of instruction (Herron & Wheatly, 1974). Bybee (1978), based on his research of teacher perceptions found that adequate student-teacher interpersonal relationships were key factors in the "ideal science teacher". There was also further support for the role of the teacher in shaping student perceptions of the classroom learning environment (Hofstein et al., 1979; Kahle & Yager, 1981; & Lawrenz & Welch, 1983). Power (1977), however, suggested that the student's role was also crucial in terms of the class environment generated and the teacher's role may not be as central as has been assumed in the past. This issue represents an interesting problem for further exploration. Assessments of different science classroom learning environments with the same teacher may prove insightful.

Another issue brought forward by Power (1977) was that of the feasibility of changing a classroom learning environment. He found that in terms of changing the classroom interactions "evidence has been presented that the introduction of a specific set of curriculum materials does not necessarily change the pattern of interaction observed in the classroom" (p. 10). This question of whether or not the classroom environment can be changed is very important to those concerned with improving their teaching situation. If it is not possible to change the environment, then research into classroom learning environments would be far less meaningful. This problem deserves further investigation through the use of intervention techniques and reassessments of the learning environment over time.

Future Studies

There appeared to be in most of the pertinent literature reviewed, considerable promise for further classroom learning environment research. Further understandings about the environment were deemed important because of the quality of the educational experience for both students and teachers and their influence on expected learning outcomes of that experience. Walberg and Haertel (1980), based on their review of research, identified some further promise for this research in their conclusion that

> Because learning environment assessments are convenient, practical, and inexpensive, because of their demonstrated predictive validity and revealing, reliable sensitivity to education innovations, and because research information from them proves interesting, meaningful, and suggestive to educational policymakers and practitioners, they are being used in a wide variety of evaluation and research projects in many countries. It seems likely that this thriving, young tradition of environmental assessment, because it balances and complements the older tradition of standardized cognitive measures, will continue to grow in size, theory, vigor, and utility. (p. 236)

Furthermore, Power (1977), in an extensive review of different types of classroom interaction studies also supported the call for further classroom environment research. He concluded

> There are sound logical and practical reasons for continuing to study classroom phenomena. After all, whatever effects schools, curricula and teachers can and do have on students derive basically from the interactions among students, teachers, and materials. (p. 25)

In this study, attempts were made to gain further insights into the complexities of the science classroom learning environment and to provide suggestions as to how these complexities could be manipulated in order to promote a desired student learning outcome, positive student attitudes toward Grade 10 science.

2.2.7 REVIEW AND ANALYSIS OF STUDIES WHICH WERE SIMILAR TO THE EMPIRICAL LINE OF THIS STUDY

There were, in the educational research reviewed, a few studies which investigated a similar problem or incorporated a similar research design as was used in the empirical line of investigation in this study (Fraser, 1978b; Haertel et al., 1981; Haladyna & Shaughnessy, 1982; Haladyna et al., 1982, 1983; Hasan, 1985; Hofstein et al., 1979; Lawrenz, 1976a,b; & MacMillan & May, 1979). It is because of these similarities that these studies were analyzed in greater detail.

List of Studies

a) Frances Lawrenz (1975, 1976a, 1976b, 1977) utilized the LEI (Anderson, 1971) to explore relationships between the student perceived learning environment and science student learning outcomes at the high school level. Of particular significance was the 1976b investigation which attempted to predict student attitudes toward chemistry, biology, and physics from these student perceptions. A total of 238 randomly selected classes had both their attitude toward the subject science, as measured by the widely used Scientific Attitude Inventory (SAI) (Moore & Sutman, 1970) and their perceptions of their classroom learning environment assessed. Their attitude scores were then related to ten independent variables or subscales on the LEI (Anderson, 1971) using a stepwise multiple regression analysis. The ten subscales predicted 29-39% of the variance in attitude toward science. The learning environment variables which made the greatest contribution to the attitude variance, in order of significance, were: favoritism, goal direction, friction, diversity, and difficulty.

The significance of this study was that it showed that student attitudes were likely related to factors in the classroom environment. There were two problems noted by the researcher, however, which may put into question the final results. Firstly, the SAI has been critically evaluated by Munby (1983) in a factor analysis of 30 studies in which it was used and by Nagy (1978) in a cluster analysis. This instrument was found not to assess the construct of an attitude toward science. Moreover, visual inspection, both by the present researcher and by Gauld (1982), indicated that it had items which assessed scientific attitudes or knowledge about characteristics of scientists rather than attitudes toward science. Secondly, it was not clear how and why the ten subscales of the 15 possible subscales of the LEI (Anderson,1971) were selected. No systematic method for selection was indicated in the published article. In this study a systematic selection technique was used to decide which variables would be investigated.

b) Paul Gardner (1976), who has also done reviews of attitude toward science assessments (1975a,b), conducted an investigation to determine the personal and environmental influences of student attitude toward physics. It was hypothesized that attitudinal variables were important predictors of future career decisions and physics course selections. A total of 58 Australian Grade 11 classes under 40 different teachers in 34 schools provided the data base. Three instruments were developed to assess: the influences of student attitudes to Physics, student personal preferences, and a physics classroom index. These instruments were administered at the beginning and end of the school year. T-tests for correlated samples were carried out to detect significant differences in student attitude, pupil and teacher characteristics and stability of teacher characteristics. It was concluded that students had a sharp decline in their enjoyment of physics over the year. However, he noted highly motivated students of achievement oriented teachers maintained a "high" level of enjoyment.

c) Barry Fraser has made numerous significant contributions to both science attitude and classroom learning environment research. Indeed, the focus of the empirical line of investigation in this study paralleled some of the work of this science education researcher. Fraser (1978b) attempted to determine which of nine environmental variables from the LEI (Anderson & Walberg, 1976) were factors in the prediction of student attitudes toward sources of scientific information. These sources were namely; conducting experiments, consulting experts, reading a book, and asking a teacher. Over 500 Australian grade seven students had their attitudes toward these sources of information assessed using four subscales of Meyers (1969) Test of Interests . Student perceptions of their science classroom learning environment, measured at midyear, were used as predictors of attitude toward these four sources of information. Pretest performance, socioeconomic status, and gender were taken into account in a multiple regression analysis for each source of information. Attitudes toward these sources were the dependent variables while 13 other variables, nine of which were from the LEI, were the independent variables. Significant relationships between the learning environment and student attitudes were found for each of the sources. Moreover, 9-11% of attitude variance was predicted by the learning environment variables.

The significance of Fraser's study (1978b) was found in that attitudinal outcomes to which positive attitudes were desirable, were specified. This specification allows for more precise information about what attitudes were toward. However, as Hofstein, Gulzman, Ben-Zvi, & Kempa (1977) found in their analysis of Meyer's (1969) attitude test, there were problems with the reliability and validity of this instrument. In this study science related behaviors were specified by using the Ajzen and Fishbein (1980) format for attitude assessment.

d) MacMillan and May (1979) attempted to define factors which influenced attitudes toward the subject science of junior high students. A total of 53 students in Denver, Colorado were randomly selected for an eight question semistructured interview. This interview was concerned with student perceptions of their science class. Responses were categorized and nominally ranked by frequency in an attempt to determine significant factors. Aspects of the classroom learning environment such as the interpersonal relationships and specific activities were found to be important.

The significance of this study is that an interview approach was used for the collection of data. It is believed, however, that greater precision in the interview data could have been attained through more detailed questioning. In this study, structured interviews of randomly selected students were utilized to not only add to knowledge of variables that influenced student attitudes toward Grade 10 science, but also allowed for the development of suggestions as to what teachers could do in their environment in order to improve them.

e) Haertel et al. (1981) attempted to synthesize the data collected from previous learning environment research. Correlations between student environment, as assessed by the LEI (Anderson & Walberg, 1976) were related to student learning outcomes. One of these learning outcomes was an attitudinal dimension. Attitudinal criteria included factors such as interest and motivation measures and self concept tests. This clustering of concepts and calling them "attitudinal" lead to further confusion of just what an attitude represented. However, given this broad attitudinal construct, 284 correlations from 10 independent studies were analyzed for significant correlations. In the analysis, the magnitudes of the correlations of learning environment scales within the student attitudinal construct were subjected to modified regression analysis. Specific learning environment variables from the LEI (Anderson & Walberg, 1976), along with other factors such as sample size, grade level, location, unit of analysis, and content area were the independent variables. The attitudinal measures represented the dependent variable. The results of the analysis, which involved the learning environment scales, illustrated that student attitudinal outcomes were positively related to cohesiveness, satisfaction, task difficulty, formality, goal direction, democracy, environnment, and competition subscales of the LEI (Anderson & Walberg, 1976) and negatively related to friction, cliqueness, speed, apathy, favoritism, disorganization, and diversity subscales. These scales accounted from .02 to .23 of the variance in attitude. The magnitude of the correlations depended upon, according to their analysis, specific scales concerned, level of aggregation, and country but not on sample size, subject matter, content subject or statistical adjustments for ability and pretest.

The significance of the Haertel et al. (1981) study was that, firstly, the positive and negative relationships between the learning environment scales and learning outcomes were empirically determined. This determination was useful when conclusions about the associations between these variables and student attitudes were inferred. Secondly, this study was a well organized attempt at synthesizing a significant amount of research. However, it should be noted this synthesis of research might assume valid and reliable attitude assessments which may not have been the case as was indicated by the previoulsy noted concerns about poor attitude instruments which have been used.

f) Hofstein et al. (1979), after citing research which supported an association between classroom learning environment and attitudes of students, attempted to verify this association. A total of 400 available Grade 11 Israeli students from 12 classes had both their perceptions of the learning environment and their attitudes toward chemistry assessed. Student scores on 13 scales of the LEI (Anderson & Walberg, 1976), the independent variables, were associated with researcher developed attitude assessment scores. The attitude assessment involved four factors, namely, attractive and exciting, clear and understandable, necessary and useful, and inexact and confusing. These attitude factors were associated to variables in the LEI (Anderson & Walberg, 1976) using two cannonical correlational analysis. Based on these analyses, the authors concluded that learning environments with high goal direction and satisfaction and low disorganization were related to positive attitude factors. Furthermore, environments with high difficulty, friction and speed, were related to a low, clear and understandable attitude factor.

The significance of this study is that it illustrated the importance of a positive classroom learning environment for promoting positive student attitude. Furthermore, it also revealed the need for a clear specification of attitudinal constructs to be investigated.

g) More recently there has been greater progress in research which attempted to identify variables within the classroom learning environment that influenced student attitudes toward science. Haladyna and Shaughnessy (1982) and Haladyna et al. (1982, 1983) have made significant contributions in this identification. A major contribution involved the establishment of a theoretical association, in a model, which linked the possible influential factors in a logical manner. This model was utilized to provide a general perspective on variables which could influence student attitudes toward Grade 10 science.

Using this model, Haladyna et al. (1983) proposed that the student, teacher, and learning environment, both within and outside the schooling process, were major determinants of student attitudes toward the subject science. Forty-four predictor variables were defined and assessed in relation to student attitudes toward the subject science in a sample of Oregon fourth, seventh, and ninth grade students. These attitudes were measured by a self report attitude inventory (Haladyna and Thomas, 1979). Learning environment variables were assessed by the LEI (Anderson & Walberg, 1976) as well as other assessments. A product moment correlation and regression analysis was used to determine the "best model" of predictor variables. The researchers concluded that, for ninth grade students, the following learning environment variables made significant contributions to the attitudinal variance: the class environment, attentiveness, cohesiveness, materials usage, and formality. Other findings included: boys' attitudinal variance predicted from learning environment was 23.3% compared to 32% for girls ; very little evidence for significant contributions of outside school variables was found ; student perceptions of overall teacher quality which involved teacher enthusiasm, teacher support for students, teacher praise, and fairness to students provided the most consistent relationships ; student perceptions of the class learning environment were related to student attitudes.

The significance of the Haladyna et al. (1982, 1983) studies went beyond the provision of a model which helped put this study into perspective. First, it illustrated the importance of the teacher in influencing student attitudes toward the subject. Moreover, the effect of the teacher on student attitudes was investigated further during the inteview aspects of this study. Second, it identified other factors or variables which may or may not be important in terms of student learning outcomes. These variables may provide a source of problems for future science education attitudinal research. For example variables outside of school, were found not to be significant influences of student attitude. However, this question of influence perhaps deserved a more detailed investigation (Hasan, 1985).

h) Haladyna and Shaughnessy (1982) attempted to synthesize quantitatively the results of previous attitude toward science research. This research was in response to some of the previously mentioned lack of integrative findings in the area (Peterson & Carlson, 1979; & Pearl, 1973). A total of 49 attitude studies, done between 1960 and 1980, were initially selected for a meta-analysis (Glass, 1976). In this analysis they attempted to determine correlates of attitudes toward the subject science. Only 19 of these studies had sufficient data within them for the analysis. Four studies which used the LEI (Anderson & Walberg, 1976) were identified and analyzed. In terms of the student perceived classroom environment, the authors concluded that the satisfaction, speed, apathy, favoritism, goal direction, and disorganization variables were highly related to student attitudes.

Haladyna and Shaughnessy (1982) concluded that "studies reveal the potency for learning environment variables as predictors of attitudes toward science" (p. 557). Moreover, they also concluded "the evidence is not yet conclusive as to which of these teacher and learning environment variables are most predictive" (p. 558). It was this uncertainty of what learning environment variables influence student attitudes that provided some of the impetus for this study.

(i) Hasan (1985) investigated the influence of some selected instructional, (e.g. teacher motivation) student motivational (e.g. number of science hobbies) , and outside cultural (e.g. parents education) variables as related to student attitudes toward science in a sample of 313 eleventh grade students in Jordan. Student attitudes were assessed toward: feelings and beliefs about scientific knowledge, faith and commitment to the methodology of science, feelings and opinions about interactions of science in society, ideas and opinions held about scientists, and finally, perceptions and ideas held about the aims of science. Once again we have confusion. The construct of an attitude toward science has been "mixed" again with a collage of constructs.

Given this assessment, confused as it is, student attitude toward science scores on the author's own instrument, were related to these instructional, student motivational, and outside cultural variables using a multiple regression technique. These variables accounted for a total of 6.3% of the variance in attitude scores. Based on this rather low account in variance, the author concluded " other variables should be sought and investigated to explain the remaning large portion of variance in attitude scores" (p. 11). This study investigated some of these other variables, namely, classroom learning environment variables.

Summary of the Literature

In summary then, the review of literature indicated that the improvement of student attitudes toward science is a desirable goal for science education programs. Further, associations have been proposed between having positive student attitudes and their likely influence on present and future learning, interests and hobbies, and future science course and career selection. Some researchers have alluded to the difficulties associated with the teaching for and evaluation of attitudinal objectives. It has been noted that attitude research has not produced consistent results. Moreover, there have been suggestions as to how this research could be improved. Some of these needs and intended contributions of this study in order to address them are presented in Figure 5.

Figure 5

Needs Identified in the Literature and Intended Contributions of this Study

Needs

1. theoretical foundation to guide attitude research in terms of attitude definition and measurement

2. empirical validation of instruments used to measure attitude based on some theory

3. greater clarification of what variables influence student attitudes toward the subject science

4. extension of attitude research to educational practice

Intended Contributions

1. describe and analyze the Ajzen & Fishbein theory in a science education context and to use this theory to define and measure student attitude.

2. attempt to empirically validate an attitude instrument which has some theoretical foundation

3. further investigate, using both regression and interview techniques, variables that influence student attitudes

4. extend the work of Joyce & Weil (1980) in terms of the adaptation of an attitude theory to improve educational practice

Chapter 3

METHOD OF STUDY

This chapter includes: a review of the problem, a description of the population and sampling plan, the instrumentation and instrument validation techniques, the data collection procedures, and the methods of data analysis.

3.1 REVIEW OF THE PROBLEM

The problem was to investigate theoretical and empirical relationships between science classroom learning environment variables and student attitude toward the subject science and to use the findings of this investigation interpretively to design a teaching/learning strategy in order to improve these attitudes.

The first line of investigation into this problem involved the description of a theoretical notion of the relationship between student attitude toward the subject science and classroom learning environment variables. This notion was extended to include a description of how classroom learning environment variables could be manipulated in order to promote positive student attitudes toward Grade 10 science. This description, given in chapter 2, was based on the writings of Haladyna et al. (1982,1983) and Ajzen and Fishbein (1980).

The second line of investigation involved the determination of the nature and strength of the empirical relationship between classroom learning environment variables and student attitude toward Grade 10 science. This determination was accomplished in two ways. First, there was the identification of classroom learning environment variables Grade 10 science teachers reported they could control, and the determination of the extent to which measures of these variables contributed to the variance in measured attitude. The second way involved the analysis of student interviews.

The third line of investigation involved an interpretation of the theoretical and empirical relationships identified in this study in order to design a teaching/learning strategy which could be used to improve these attitudes. This design followed a format for the application of theories to educational practice proposed by Joyce and Weil (1980).

3.2 POPULATION AND SAMPLING PLAN

3.2.1 DESCRIPTION OF THE ACCESSIBLE POPULATION

The accessible population, from which a sample was selected, was defined by the total number of students enrolled in Grade 10 science classes within the Kamloops School District. There was a total of 1,139 students enrolled in 46 classes of Grade 10 science. These 46 classes were taught by 24 different teachers. This District which is located in the interior region of the Province of British Columbia, had 42 elementary and 11 secondary schools in January of the 1984-85 school year. There were six urban and three rural schools which offered Grade 10 science.

The Grade 10 science course guidelines were provided in the British Columbia Junior Secondary Science Curriculum (1983). The text prescribed for the course was Science Probe (Bullard et al., 1984). Teachers were expected to follow the guidelines of this Provincial curriculum.

3.2.2 SAMPLING PLAN-ACCESSIBLE POPULATION

From the list of 46 Grade 10 science classes (clusters), 12 classes of students were randomly selected. The participation of these students was contingent upon the approval of the science teachers and individual students involved. One teacher refused to have his students participate in this study.

Another class of students was therefore randomly selected from the remaining classes. A total of 245 students were in the sample. The number of students for whom complete data was collected was 231. This sample of 231 students represented 20.3% of all the Grade 10 science students in the District and approximately 0.03% of the Grade 10 students in the Province of British Columbia in the 1984-85 year.

Statistically the empirical results of this study were generalizable to Grade 10 students in the Kamloops School District. The researcher held, however, that with caution, these results were likely generalizable to a target population of Grade 10 science students in the Province of British Columbia. This position was based on the following considerations. First, the use of a cluster sampling technique reduced selection bias. Second, the Kamloops District included both rural and urban schools. Third, the Grade 10 science curriculum and text were the same across the Province. However, no data was obtained to establish further congruency between the accessible population and the target population.

Twenty students from the sample were selected at random for the purpose of participation in a structured interview with the researcher. Of these 20 students, 16 were available for the interview.

Forty-four students from two science classes in the sample were selected for participation in the retest of the Attitude Toward the Subject Science Scale (ATSSS). Similarly, 26 students from two classes were selected for the retest of selected variable scales on the Learning Environment Inventory (LEI). Students in these classes were selected on the basis of convenience of scheduling.

Volunteer Grade 10 science teachers from the Kamloops School District were asked to participate in an interview with the researcher. Fifteen teachers participated in this interview.

3.3 INSTRUMENTATION

3.3.1 SELECTION OF TEACHER CONTROLLABLE VARIABLES FROM THE LEARNING ENVIRONMENT INVENTORY, (LEI)

The classroom learning environment was operationally defined by the 15 variables of the LEI. (Fraser, Anderson, & Walberg, 1982). The description and meaning of each of these variables along with a sample item is given in Table I.

Only those variables from the LEI that Grade 10 science teachers reported they could control in a classroom teaching situation were investigated. The selection of controllable variables was accomplished by the use of the Learning Environment Inventory Analysis (LEIA). In this scale verbatim descriptions and meanings of each of the 15 LEI variables were presented to a sample of 20 Grade 10 science teachers in the District. These teachers were asked to rate, on a 0-6, no control/total control scale, the degree of control they had over each of the variables. This control was summarized by the mean teacher ratings for each of the 15 variables on the LEIA. A sample copy of the LEIA is located in Appendix A.

Table I

LEI Variable Descriptions and Sample Items

Variable	Variable Description	Sample Items
Cohesiveness	Extent to which students, know, help and are friendly toward each other.	All students know each other very well. (+)
Diversity	Extent to which differences in students' interests exist and are provided for.	The class has students with many different interests. (+)
Formality	Extent to which behavior within the class is guided by formal rules.	The class is rather informal and few rules are imposed. (-)
Speed	Extent to which class work is covered quickly.	Students do not have to hurry to finish their work. (-)
Material Environment	Availability of adequate books, equipment, space, and lighting.	The books and equipment students need or want are easily available to them in the classroom. (+)
Friction	Amount of tension and quarrelling among students.	Certain students in the class are responsible for petty quarrels. (+)
Goal Direction	Degree of goal clarity in the class.	The class knows exactly what it has to get done. (+)
Favoritism	Extent to which the teacher treats certain students more favorably than others.	Every member of the class enjoys the same priveleges. (-)
Difficulty	Extent to which students find difficulty with the work of the class.	Students in the class tend to find the work hard to do. (+)
Apathy	Extent to which students feel no affinity with the class activities.	Members of the class don't care what the class does. (+)
Democracy	Extent to which students share equally in decision-making related to the class.	Class decisions tend to be made by all the students. (+)
Cliqueness	Extent to which students refuse to mix with the rest of the class.	Certain students work only with their close friends. (+)
Satisfaction	Extent of enjoyment of class work.	There is considerable dissatisfaction with the work of the class. (-)
Disorganization	Extent to which classroom activities are confusing and poorly organized.	The class is well organized and efficient. (-)
Competitiveness	Emphasis on students competing with each other.	Students seldom compete with one another. (-)

Items designated (+) are scored 1, 2, 3, and 4, respectively, for the responses Strongly Disagree, Disagree, Agree, and Strongly Agree. Items designated (-) are scored in the reverse way.

3.3.2 DEVELOPMENT, USAGE, AND VALIDATION OF THE LEARNING ENVIROMENT INVENTORY (LEI)

The LEI was used to define classroom learning environment and to measure student beliefs about 10 variables which were identified as controllable by teachers. These 10 selected variables were measured by corresponding scales of the third edition of the LEI (Fraser, Anderson, & Walberg, 1982).

The initial development, use, and validation of the LEI has been reviewed in detail (Anderson & Walberg, 1974a,1976; Fisher & Fraser, 1981; Fraser, Anderson, & Walberg, 1982; & Walberg & Haertal, 1980). A brief suumary of this work follows:

The theoretical underpinnings of the LEI were derived from the Getzels and Thelan (1960) model for the classroom as a social system. This model holds that in school classes personality needs, role expectations, and classroom climate interact to predict group behavior. Using both this model and observations of classrooms as starting points, a number of classroom climate variables were derived. These variables included: interpersonal relationships among pupils, relationships between pupil and teacher, relationships between pupils and the methods of instruction, and pupils' perceptions of the structural characteristics of the class.

The development of the LEI, which began as part of the research and evaluation activities of Harvard Project Physics, has included three versions. The first version of the LEI, then called The Classroom Climate Questionnaire, was developed by Walberg (1968). This version was subjected to content, item, and factor analysis (Anderson, 1971) which formed the basis for the second version of the LEI (Anderson & Walberg, 1976). Data from the administration of the second version were used, in turn, as the basis for the development of a third version which is found in the Assessment of Learning Environments: Manual for

Learning Environment Inventory and My Class Inventory (Fraser, Anderson, & Walberg, 1982).

Each variable scale on the LEI includes seven items. The respondent expresses agreement or disagreement with each statement on a four point Likert-type scale. Each variable is scored separately by summation to derive a student score for that variable. For example a high score on the Disorganization variable scale was interpreted to mean that the student believed the class was disorganized. Conversely, a low score on this variable scale was interpreted to mean the student believed the class was not disorganized.

Internal consistenty reliability estimates (alpha coefficients) for the 15 LEI scales were reported by Anderson and Walberg (1974a) to range from 0.54 to 0.85 with a mean of 0.72 for a sample of 1048 individual high school students. Test-retest reliabilities (stability over time) ranged from 0.43 to 0.73 for the 15 scales. Discriminant validity indices (LEI scale intercorrelations) were reported by Anderson and Walberg (1976) to range from 0.00 to 0.71 with a mean of 0.27 based on the means of 149 classrooms. This validation data for the LEI is reported in Table IX and Table X in Appendix B.

The LEI has been shown to identify differences among classes (Anderson, 1973; Lawrenz, 1976b), to be related to student attitudes toward science (Lawrenz, 1975, 1976a), and to be stable over the school year (Lawrenz, 1977). Randhawa and Fù (1973) reported that this instrument had been used over 300 times in various research studies in 10 different countries. Chavez (1984) reported that the LEI has been the most commonly used learning environment instrument in educational research.

Given the considerable amount of validation data on the LEI, it was seen as a valid, reliable instrument for the purposes of this study. Nonetheless, further tests on this instrument's reliability were conducted in the context of this study. The 10 scales which represented measures of the variables that were reported to be controllable by teachers, were subjected to post-hoc internal consistency reliability, and 3-4 week test-retest reliability assessments. The internal reliablility estimates for the ten scales ranged from 0.62 to 0.81. The test-retest reliability coefficients ranged from 0.60 to 0.88. This additional data on the LEI is reported in Table XI in Appendix B.

3.3.3 VALIDATION OF THE ATTITUDE TOWARD THE SUBJECT SCIENCE SCALE (ATSSS)

The ATSSS was developed by the researcher in order to assess student attitude toward the subject science. This scale was developed in accordance with the Ajzen and Fishbein (1980) guidelines for attitude assessment previously described in chapter 2.

The ATSSS underwent development and testing for both its reliability and validity, in terms of assessing student attitudes toward the subject Grade 10 science. This development and testing followed some of the guidelines for attitude scale construction proposed by Koballa (1984a) and Nyberg and Clark (1982).

A pool of 21 items was drafted. These items were constructed using the format put forward by Ajzen and Fishbein (1980). It was important for items on this instrument to be congruent with this format because the foundation of attitude assessment was based on the Ajzen and Fishbein (1980) theory. Two researchers familiar with the theory guidelines, examined this draft for that congruency. The items on the ATSSS were concerned with various behaviors related to the teaching and learning of Grade 10 science. Four teachers of Grade 10 science reviewed these items and based upon these reviews suggested other behaviors which were salient in the teaching and learning of Grade 10 science. Based on these reviews of the items, the scale was revised.

Ajzen and Fishbein (1980) defined attitude as an evaluative or affective response to performing a specific behavior. Moreover, since they recommended the use of semantic differential-type scales to evaluate behaviors, it was important to use empirically validated evaluative scales in the attitude instrument.

Nyberg and Clarke (1982) conducted a study in Alberta, Canada in order to develop an instrument to assess student attitudes toward various school subjects. They also used a semantic differential technique (Osgood et al., 1957). In their process of instrument development they found 11 adjective pairs which loaded highly on the evaluation factor for grades 5, 8, and 11. Three suitable pairs were selected and used in all the ATSSS items. These pairs were selected on the basis that they had to make sense for each item. The pairs selected were : nice-awful; interesting-boring; and pleasant-unpleasant.

After the preparation and evaluation of the second draft, the instrument was piloted in an available Grade 10 science class in the Vancouver School District. Based on student feedback and an analysis of the internal consistency of the items the instrument was revised. Items with item-total correlations corrected for overlap below 0.40 were eliminated from the pool. Moreover, items with which students had difficulty were rewritten or eliminated. This third version of the ATSSS was then subjected to tests of validity and reliability in the accessible population in which it was to be used.

The ATSSS was tested in a pilot study in the Kamloops School District. In this pilot the researcher administered the instrument to 33 students in two available science classes in the District and readministered to these classes 3 to 4 weeks later. Based on these administrations, a test-retest reliability coefficient of 0.84 and an internal consistency reliability estimate of 0.96 were obtained.

In addition to tests of reliability, two approaches were used to establish the validity of the ATSSS. Firstly, teachers of two available science classes in the District were asked to rank order the students in their class in terms of most positive attitude toward the subject science. The teacher's rank order of students was correlated to the student's rank order on the ATSSS scores. A Spearman-rank order coefficient was computed for each of the two classes involved. These coefficients were 0.79 (n=25) and 0.65 (n=19).

The second approach entailed a comparison between the student ATSSS score to a reliable attitude toward the subject science scale, the School Science scale. This scale was developed as part of the British Columbia Science Assessment (1982). Internal consistency reliabiltiy of this scale was reported to be 0.89 (n=869). A sample copy of this scale is located in Appendix D. Student scores on this instrument, from four available classes in the District, were correlated with their corresponding score on the ATSSS. This correlation was 0.70 (n=76).

In terms of the overall validity assessment of the ATSSS, there was an overall correlation coefficient calculated for the two approaches. This calculation was based on an arbritary weighting of each of the coefficients. The School Science coefficient, because it was based on a previously validated instrument, was given a 0.75 weighting. The teacher comparison coefficients were given a 0.25 weighting. The overall coefficient of correlation was 0.71.

The ATSSS underwent further testing adhoc for its reliability over time. This test entailed a readministration of the instrument approximately four weeks after the initial data collection. The test-retest correlation coefficient revealed was 0.82 (n=44). Moreover, an additional test of instruments validity was carried out by a comparison of student attitude scores on the Classroom Factors that Influence Student Attitude interview schedule to their corresponding score on the ATSSS. This correlation was 0.81 (n=16). A sample copy of the ATSSS is located in Appendix C.

3.3.4 DEVELOPMENT OF THE CLASSROOM FACTORS THAT INFLUENCE STUDENT ATTITUDE INTERVIEW SCHEDULE

Further information about the relationship between classroom learning environment variables and student attitudes toward Grade 10 science was gathered through student interviews. In order to obtain this information, the Classroom Factors that Influence Student Attitude interview schedule was developed.

This schedule consisted of three sections. The first section was one of introduction which included an overview of the purpose and directions for the interview. The second section reassessed student attitudes toward the subject science. The third section provided an indication of which science classroom learning environment variables were related to student attitudes toward Grade 10 science.

Initially the interview schedule was drafted by the researcher. Feedback on the clarity and utility of the schedule was obtained from two science educators at the University of British Columbia. Based on this feedback the instrument was revised. This revision was examined by two other science educators for its face validity for the purpose of obtaining information about student attitudes toward the subject and an indication of science classroom variables which may be related to these attitudes. Based on this examination, the instrument was further revised.

The schedule was piloted by the researcher in interviews with two Grade 10 students from the sample. For the purpose of obtaining an indication of the schedule's reliablity, one of the students was reinterviewed four weeks later. The responses to each question were compared for their congruency by the researcher. The congruency was viewed as satisfactory. A sample copy of this schedule is provided in Appendix E.

3.4 DATA COLLECTION

The collection of empirical data proceeded in steps. These steps were:

1. The determination of those variables from the LEI (Fraser, Anderson, & Walberg, 1982) which teachers reported they had control over. Twenty available teachers of Grade 10 science in the Kamloops School District rated each of the 15 variables in terms of teacher control. This rating on the LEIA scale was done in the presence of the researcher.
2. The administration, by the researcher, of both the ATSSS and selected scales of the LEI to 231 students in the sample was done during one class period for each class involved.
3. The readministration, by the researcher, of the ATSSS and the adapted LEI for the purpose of reliability and validity checks. Complete data was available for 44 students for the ATSSS and 26 for the LEI. This readministration occurred 3 to 4 weeks after the initial administration at a mutually convenient time.
4. The interviews, by the researcher, of 16 students from the sample using the Classroom Factors that Influence Student Attitude interview schedule. This interview, which took about 15 minutes, took place in any convenient location in the school during the lunch hour. Student responses were summarized on the interview schedule by the researcher.
5. The interviews, by the researcher, of 15 Grade 10 science teachers from the sample. In this interview data was collected on suggestions teachers had for improving student attitudes toward Grade 10 science. These interviews took place in any convenient location in the school at a mutually convenient time. The results of this interview were recorded by the researcher on a question sheet. A sample copy of a completed sheet is located in Appendix F.

3.5 METHODS OF ANALYSIS

The first line of investigation involved the description of a theoretical notion of the relationship between classroom learning environment variables and student attitude toward the subject science. This description involved the abstraction, from the works of Haladyna et al. (1982,1983) and Ajzen and Fishbein (1980), a theoretical notion of how student attitude toward Grade 10 science could be related to variables within a classroom learning environment. In this abstraction key aspects of this notion were interpreted and used in the design of a teaching/learning strategy which could be used by classroom teachers in order to improve these attitudes.

The analysis of empirical data, as related to the second line of investigation, proceeded in steps which follow closely the steps of empirical data collection (Section 3.4).

The first step involved the determination of which classroom learning environment variables, as defined in the LEI, Grade 10 science teachers reported they could control in a teaching situation. The degree of reported teacher control for each of the 15 variables was determined by the calculation of the mean teacher rank on degree of control for each of these variables. The variable with the highest rank was viewed as the variable teachers reported they had the most control over. In order for a variable from the LEI to be deemed controllable, it had to have a mean scale score above the mid-point of the no control-total control rating scale. Given this provision in absolute terms, the researcher arbitrarily decided that the following categorization would describe the relative degree of control for each of the described variables: The five variables with the highest mean rank were deemed "most controllable", the five next highest deemed "moderately controllable", and the last five were deemed "least controllable". The top ten highest ranking variables were considered in this investigation.

Given the teacher ratings of control, there was a further analysis of these ratings for the degree of agreement among teachers as to which variables they reported they had control over. This degree of agreement among teachers was estimated through the calculation of Kendall's coefficient of concordance. This coefficient represented a measure of interjudge agreement.

The second step involved the determination of the nature and strength of the empirical relationship between classroom learning environment variables and student attitude toward Grade 10 science. In terms of the nature of the relationship the researcher sought a linear relationship between a measure of student attitude and a composite of learning environment variables. The determination of the strength of empirical relationship was accomplished through the use of a forward multiple regression equation. This regression equation provided an indication of which measures of classroom learning environment variables, from the LEI, made significant contributions to the variance in ATSSS measured student attitude toward Grade 10 science. The determination of whether the relationship was linear involved a visual inspection of the plot of standardized residuals in the regression equation.

In terms of this regression analysis, the independent classroom learning environment variables which made significant contributions to the variance in attitude were revealed by their order of entry into the equation. The variables which made the greatest contributions to the variance in attitude score were considered the "best" predictors of student attitude toward Grade 10 science.

The third step involved the specification of attitude influencing classroom learning environment variables from student interview data. Based on student interview responses the researcher categorized the responses which suggested specific variables as influences of student attitude toward Grade 10 science. The number of responses for each variable, from all the individuals interviewed, were rank ordered in terms of frequency. This ordering was interpreted as an indication of the strength of the relationship betweeen variables and student attitudes. These interview results were viewed as contributing to the understanding of the relationships revealed in the regression analysis. Furthermore, they were also used to identify other possible learning environment variables which were related to student attitudes toward Grade 10 science.

It was previously noted that in the investigation of the nature and strength of the relationship, other empirical information about how students and teachers viewed the teaching/learning of Grade 10 science was available. Furthermore, some of this information was used when it illuminated science education practice. The available information included: assessments of student attitudes toward behaviors on the ATSSS, assessments of student beliefs about their classroom learning environment on the LEI, and categorized teacher suggestions for improving student attitudes toward Grade 10 science.

The third line of investigation involved the design of a teaching/learning strategy based on the theoretical and empirical relationships revealed in this study. This strategy involved: the analysis of key ideas about the association between attitude and the classroom learning environment; the selection of a key relationship revealed in the empirical analysis, and the interpretation of this relationship in the context of a format for applying theory to practice suggested by Joyce and Weil (1980). The strategy was illustrated by a sample lesson from a unit of instruction developed by the researcher. The sample lesson intends to provide an example of some general principles teachers could use in an attempt to improve student attitudes toward the subject science.

Chapter 4

RESULTS

The general problem, research questions, the methods of investigation have been described in earlier chapters. The research questions are repeated here for the convenience of the reader.

1. How are student attitudes toward the subject science acquired and changed and how are these attitudes related to variables within a science classroom learning environment?
2. What is the nature and strength of the empirical relationship between classroom learning environment variables and student attitude toward Grade 10 science?
3. How can the results of this study be used interpretively to improve student attitudes toward Grade 10 science?

These three questions formed the basis for the presentation of the results of this study. These results will be reported in order of the theoretical, empirical, and interpretive lines of investigation.

4.1 THEORETICAL RELATIONSHIP

In this investigation the Ajzen and Fishbein view of attitude and attitude change and the Haladyna model of variables which could influence student attitude toward the subject science were used to describe a theoretical notion of how a student attitude toward Grade 10 science is acquired, changed, and related to behavior and how this attitude could be influenced by variables within a science classroom learning environment. The essentials of this notion have been described in chapter 2. The present discussion will focus on highlighting those essentials which are salient to improving our understanding of how these attitudes could be improved through the manipulation of the classroom learning environment.

Haladyna et al. (1982, 1983) noted that there were many possible influences of student attitudes toward the subject science. Within school learning environment variables were the focus of this study. In summary, Haladyna et al. provided a general perspective on how classroom learning environment variables were one subset of variables which influenced student attitude toward the subject science.

The Ajzen and Fishbein (1980) view of attitude was used to describe in a more specific way how student attitude toward an object is acquired, changed and related to behavior. This view was interpreted in a science education context in a description of a theoretical notion of how this attitude is influenced by the science classroom learning environment. Some of the essential aspects of this notion are reviewed below.

1) Experiences in the science classroom lead to the learning by students of what constitutes the learning environment for the subject science.

2) Classroom learning environment variables were viewed as related objects to the subject Grade 10 science, the attitude object.

3) The learning about related objects, such as the classroom learning environment, is accompanied by an evaluation of these related objects.

4) Through association of related objects (classroom learning environment variables) with the attitude object (subject Grade 10 science), evaluations of the environment are associated with evaluations of the subject. In this way then through association, the learner acquires a predisposition to evaluate the subject Grade 10 science in a consistently favorable or unfavorable way.

5) Student beliefs about Grade 10 science, and their evaluation of outcomes of behaviors related to the subject, influence their attitude toward the subject.

6) Positive attitudes toward Grade 10 science can be learned through presenting

information to students about positive outcomes of performing specific behaviors within the science classroom learning environment.

7) Negative attitudes toward the subject Grade 10 science can be changed by presenting information to:

a) form new beliefs about performing behaviors associated with classroom learning environment variables

b) eliminating previously learned beliefs about negatively evaluated behaviors associated with classroom learning environment variables

c) introducing new related objects through the presentation of experiences, which can be subsequently associated with the subject Grade 10 science.

The previously described essential aspects of the theoretical relationship between student attitude and student beliefs about the classroom learning environment were used to guide the design of a teaching/learning strategy which could be used to improve student attitudes.

4.2 EMPIRICAL RELATIONSHIPS

The identification of the nature and strength of empirical relationship between classroom learning environment variables and student attitude toward the subject science was accomplished through the use of a forward regression analysis technique. Further information on the nature and strength of this relationship was also sought from student interview data.

The empirical line of investigation also allowed for the collection of additional data. This data included information about student attitudes toward the subject science, student beliefs about the classroom learning environment, and student and teacher suggestions regarding how Grade 10 science instruction could be improved.

The steps leading to the identification of the nature and strength of the relationship follows.

4.2.1 DETERMINATION OF REPORTED TEACHER CONTROL OVER VARIABLES DEFINED ON THE LEI

It was previously noted that the investigation of empirical relationships between classroom learning environment variables and student attitudes toward the subject science involved the pre-selection of learning environment variables that teachers reported they could control in a teaching situation. Teachers were asked to report the degree of control they had over each of the 15 variables described in the LEI on the Learning Environment Inventory Analysis (LEIA). As was previously mentioned, the 10 most controllable variables were considered in this investigation. The rank order of degree of control from most to least controllable, along with standard deviation and mean score for each is given in Table II.

Table II

Degree of Reported Teacher Control
of Variables on the LEI

Variable	Mean Rank	Std. Dev.	Mean Score
Disorganization	13.15	0.61	5.5
Goal Direction	12.65	0.57	5.3
Formality	11.32	0.51	5.0
Favoritism	11.27	1.00	5.0
Democracy	10.60	0.97	4.8
Speed	9.97	1.00	4.5
Satisfaction	7.22	0.93	3.7
Apathy	7.13	1.35	3.6
Competitiveness	7.10	1.50	3.6
Difficulty	6.70	1.15	3.5
Friction	5.95	1.57	3.1
Diversity	5.00	0.92	3.0
Cohesiveness	4.52	1.06	2.8
Cliqueness	3.52	1.09	2.4
Material Environment	3.05	1.59	2.3

According to these ratings which are given in Table II, the most controllable variables, from more to less control were: Disorganization, Goal Direction, Formality, Favoritism, and Democracy. The moderately controllable variables, from more to less control were: Speed, Satisfaction, Apathy, Competiveness, and Difficulty. The least controllable variables, from more to less control were: Friction, Diversity, Cohesiveness, Cliqueness, and Material Environment.

These teacher ratings of control, were further analyzed for the degree to which science teachers agreed with each other on the ratings. This degree of agreement was estimated for all 15 variables through Kendall's Coefficient of Concordance. This coefficient, W=0.56 with a χ^2 = 156.9 (14,n=20), was statistically significant at the $p<.01$ level. The descriptive statistical data, upon which Table II is based, is located in Appendix G.

The results of the analysis on degree of teacher agreement, W=0.56, suggested that Grade 10 science teachers agreed on what they could or could not control in a classroom teaching situation. For some variables, however, there was a more significant degree of agreement. For example, based upon the examination of the standard deviations in the ratings of each variable, as seen in Table II, teachers had the highest degree of agreement on the extent to which they could control the Formality, Organization, and Satisfaction variables of a classroom learning environment. Furthermore, teachers had the lowest degree of agreement on the potential control of the Material Environment, Friction, and Competitiveness variables.

4.2.2 RESULTS OF FORWARD REGRESSION ANALYSIS

The determination of which measures of student beliefs about the classroom learning environment were related to the measure of student attitude toward Grade 10 science, was done through the use of a regression analysis technique. The dependent or criterion variable, student attitude toward the subject science, was measured by the ATSSS. The independent variables or predictors, were those LEI variables reported to be controllable by Grade 10 science teachers. A forward regression analysis was selected as the statistical means for determining which measures of classroom learning environment variables made significant or little contribution to the variance in attitude scores. This analysis was selected because of the strictness of the entry requirements for a variable. This strictness was sought for the purpose of identification of the most highly related learning environment variables. A summary of the results of the forward regression analysis are given in Table III. The more detailed data from the computer output for this analysis is located in Appendix H.

Table III

Forward Regression of Independent Learning Environment Variables to the Dependent Measure of Student Attitude

Variable	R^2	ΔR^2	F	B
1. Satisfaction	0.235	0.235	70.34	0.31
2. Apathy	0.272	0.037	42.54	-0.24
3. Difficulty	0.289	0.017	30.69	-0.16

Table III shows the order of entry of three independent learning enivronment variables into the equation, the total contribution to the variance in attitude score (R^2); the extent of the additional contribution of each of these variables to the variance in attitude scores (ΔR^2); the F value calculated for the determination of statistically significant contributions; and the standardized Beta coefficient (B) which indicates the direction of the associations. The order of entry into the equation and the contribution to the variance in attitude score was interpreted as an indication of the strength of the empirical relationship between the selected classroom learning enviroment variables and student attitudes toward Grade 10 science. These variables in order of entry were: Satisfaction, Apathy, and Difficulty. Moreover, these three variables accounted for 28.9% of the variance. The variable Satisfaction accounted for 23.5%, the Apathy variable accounted for an additional 3.7%, and the Difficulty measure accounted for an additional 1.7%.

Satisfaction, the best predictor and first variable entered, was defined as the "extent of enjoyment of class work". For example, this work could have involved activities such as participating in science labs, doing projects, or listening to the teacher. In this analysis, based on the inspection of the standardized weighted Beta coefficient (+0.31), positive student attitudes toward the subject science were associated with the belief that students were satisfied with the work of the class.

The second best predictor of student attitudes toward the subject science was the Apathy variable. According to the LEI variable descriptions it was "the extent to which students feel no affinity with the class activities". For example, students could have different beliefs about how much fellow students care about the class. Based on the inspection of the standardized Beta coefficient (-0.24), negative student attitudes toward the subject science were related to student beliefs that class members did not care about how well class activities went.

The third best predictor of student attitudes toward the subject science was the Difficulty variable. According to the LEI variable descriptions, it was the "extent to which students find difficulty with the work of the class". For example students had differering beliefs about how difficult the subject science was. Based on an inspection of the standardized Beta coefficient (-0.16) negative student attitudes toward the subject science were related to student beliefs that the class was difficult.

In terms of the nature of the empirical relationship between measures of student beliefs about the classroom learning environment and a measure of student attitude toward Grade 10 science, it appeared to be linear. This appearance of linearity was based upon a visual inspection of a plot of standardized residuals from the regression equation. This plot is located in Appendix I.

A backward regression analysis was also undertaken for the purpose of determining whether or not any other learning environment variables made statistically significant contributions to the variance in attitude scores. In this analysis five variables made statistically significant contributions. The two other variables, in addition to the ones previously discussed, were Formality and Competiveness. These two variables accounted for an additional 2.6% of the measured variance. The influence of these variables was not investigated or discussed further in the context of this study. The computer output from the backward regression analysis is located in Appendix J.

4.2.3 STUDENT INTERVIEW RESULTS

Further information about the relationship between classroom learning environment variables and student attitude toward the subject was sought in the student interviews. This information was intended to supplement the information on the relationships revealed in the regression analysis as well as to identify other classroom learning environment variables which were related to student attitude.

Student responses to the Classroom Factors that Influence Student Attitude interview schedule were recorded on this schedule. A copy of a completed schedule and a sample transcript is located in Appendix K. A summary of categorized responses to each of the questions is provided in Appendix L. The variables which were found to be related to student attitude and the frequency of responses for each are indicated in Table IV.

Table IV

Summary of Variables Related to Student Attitude from Student Interviews

Variable	Variable Description	Frequency
	The extent to which:	
Activity	-there are hands on activities/labs	27
	-too much teacher talk	10
	-reading the text is required	5
Clarity	-there are clear/well organized teacher explanations	16
Usefulness	-taking the subject helps with future schooling/careers	15
	-science content can be related to real life	13
Difficulty	--formulas, mathematics, memorization is required	12
Relations	--the teacher has good personal relationships with students	11
	-students have friends in class	7
Satisfaction	-students enjoy the learning activities	11
Discipline	-the teacher has control of the class	7

Students were found to be very willing to volunteer information about their science class and classroom learning environment, however, some students had difficulty in expressing their ideas.

4.2.4 ADDITIONAL INFORMATION

The empirical line of investigation into the relationship between student attitude toward the subject and the Grade 10 science classroom learning environment, allowed for the collection of additional data which were used in the discussion of the implications of the findings of this study. This information was gathered in assessments of student attitudes toward the subject science by the ATSSS, student beliefs about their classroom learning environment by selected scales on the LEI, and by teacher responses to a personal interview with the researcher.

Assessments of Student Attitude Toward the Subject Science

The ATSSS, the measure of student attitude toward the subject science, included information on both the samples' attitude toward specific behaviors related to the teaching/learning of Grade 10 science, and an indication of their overall attitude toward this subject.

In terms of student attitudes toward performing 15 behaviors, the sample mean score for each of the behaviors was interpreted as an indication of student attitude toward performing each of these behaviors. The rank order of mean scores for these 15 behaviors is given in Table V.

Table V

Student Attitude Toward Behaviors
as Measured on the ATSSS.

Behavior	Mean (N=231)
1. Actively participating in science labs	16.1
2. Watching science related T.V. programs	15.2
3. Trying to get a good science mark	14.7
4. Trying to keep a good science notebook	13.8
5. Having a good attitude to taking science	13.7
6. Trying to apply science learning to life	13.5
7. Asking the teacher questions about science	13.4
8. Liking a majority of the topics taken in class	13.3
9. Reading science related magazine articles	13.2
10. Trying to do science assignments well	13.0
11. Trying to learn more science outside of class	12.5
12. Trying to solve science problems	13.0
13. Listening to the teacher talk about science	11.6
14. Trying science like experiments at home	11.3
15. Reading the science text once a week	10.2

Table V indicated that the activities which were viewed most positively in decreasing order of positiveness, were: actively participating in science labs, watching science related T.V. programs, trying to get a good science mark, and trying to keep a good science notebook. The activities which were viewed most negatively, in decreasing order of negativeness, were: reading the science text, trying science experiments at home, and listening to the teacher talk about science.

Assessment of Student Beliefs About the Learning Environment

Students in the sample also had their beliefs about 10 variables of the Grade 10 science classroom learning environment assessed. These beliefs were measured by the LEI. The overall sample mean score, on each of the variables, was interpreted as an indication of how students in the sample viewed their science class. The highest mean scale score was interpreted as indicating the greatest agreement with the scale description of the variable on the LEI as indicated in Table I. The rank order of overall mean scores for student beliefs about the classroom learning environment are given in Table VI.

Table VI

Student Beliefs About the Learning Environment on the LEI

Variable	Mean(N=231)
Difficulty	19.6
Formality	19.5
Speed	18.4
Goal Direction	18.0
Apathy	17.6
Competitiveness	17.4
Disorganization	17.3
Democracy	16.8
Satisfaction	16.1
Favoritism	15.4

It was concluded, based on the examination of the extreme mean scores, that Grade 10 science classes were viewed as being relatively: formal, difficult, unsatisfying, with few favorites.

Teacher Interviews

Fifteen teachers were interviewed for the purpose of gathering further ideas on improving student attitudes toward Grade 10 science.

The teachers were asked the following question: What can a Grade 10 science teacher do in his/her class in order to promote more positive student attitudes toward the subject science? The responses were summarized by the researcher on a question sheet. A sample of a completed interview summary is located in Appendix F.

These responses were categorized and counted in order to obtain a list of suggestions for strategies that may be used by classroom teachers. These suggestions, in rank order of frequency, are located in Table VII.

Table VII

Summary of Teacher Suggestions for Improving Student Attitudes

Suggestion	Frequency
- Emphasize the practical/social/personal aspects of science (e.g. sports, home, local examples)	14
- Use hands on activities (e.g. labs, constructing)	9
- Show a high degree of teacher enthusiasm (e.g. project a positive outlook for the value of science to the students)	6
- Have as much variety in the classes as possible (e.g. videos, labs, field trips, projects). Try to consider different abilities and interests of the students.	5
-Have exciting demonstrations (e.g. puzzling events)	3
- Try to emphasize good personal relationships within the class	3

These interviews were found to be insightful and interesting. The insight was primarily generated from the wisdom of experience of these teachers. Many of the suggestions were provided with a practical perspective of what has worked in the past. The interest came from the experience of listening to teachers concerns about their science classes and what could or could not be done, within the structure of their situations, to make science education better for both students and teachers.

4.3 DESIGN OF A TEACHING/LEARNING STRATEGY FOR THE PROMOTION OF POSITIVE STUDENT ATTITUDES TOWARD GRADE 10 SCIENCE

This section is concerned with describing how the theoretical and empirical results of this study could be applied in practice. This application involves the design of a teaching/learning strategy. This design is illustrated through both a presentation of a unit of instruction which is located in Appendix M. and the development of one sample lesson from the unit.

4.3.1 JOYCE & WEIL METHOD FOR ADAPTING THEORY TO PRACTICE

Joyce and Weil (1980) suggested a method for the adaptation of theories to educational practice. Elements of this method used to guide the adaptation of the Ajzen & Fishbein theory are described below:

Instructional Effects- should outline the desired effects of instruction on the student and the learning environment

Phasing- should describe the kinds of activities to be used and how they are sequenced and organized

Social System- should describe teacher and student roles

Principles of Reaction- should suggest to the teacher how to regard the learner and how to respond to what the learner does.

Support System- should describe the supporting materials and conditions for the strategy to succeed.

4.3.2 ASPECTS OF THE AJZEN AND FISHBEIN THEORY TO BE ADAPTED

Aspects of the Ajzen & Fishbein theory to be adapted and the relevant background reference pages in this dissertation are indicated below. This theory was used to:

a) clarify the attitudinal objective and the concept of an attitude toward the subject science (pp. 23-27)

b) explain how student attitudes toward the subject science could be formed and changed by strengthening evaluations of related objects (e.g. classroom learning environment variables) or introducing new positively evaluated related objects to become associated with the attitude object (subject science) (pp. 36-39)

c) suggest how to influence student beliefs in order to affect student attitudes through the presentation of both implicit and explicit information about consequences of performing behaviors (pp. 29-31) and (pp. 36-38)

d) explain how changes in student attitude could be related to changes in student behavior (pp. 29-31)

e) describe a means by which to assess student attitude and attitude change consistent with a specific perspective (pp. 27-29)

4.3.3 EMPIRICAL RESULTS TO BE ADAPTED

One learning environment variable, degree of student work satisfaction, was revealed in the empirical line of investigation, to be the most related to student attitudes toward Grade 10 science. The sample lesson which follows intends to show how this variable could be manipulated in the adaptation of the Ajzen & Fishbein theory.

Examples of Possible Manipulations

The teacher can:

a) consider the importance of student beliefs about work satisfaction in the formation of student attitude toward the subject science in the selection and organization of learning activities

b) attempt to change student attitudes toward the subject science by strengthening evaluations of related objects (e.g. student work satisfaction) or introducing new work experiences which could become associated with the attitude object (subject science)

c) attempt to promote positive evaluations of the work of the class through: presenting information about the consequences of behaviors and or providing feedback on the performance of behaviors associated with the work of the class

d) attempt to use the influence of peers to influence student beliefs about the work of the class

e) adjust the content or method of presentation of class work based on student evaluations of the work done in class

4.3.4 ILLUSTRATIVE SAMPLE LESSON

The following sample lesson, lesson three in the unit, intends to illustrate general principles of a strategy which may be adapted for other lessons in the unit, other learning environment variables, or other grades. The lesson is structured around the elements suggested by Joyce & Weil (1980). Table VIII summarizes the adaptations from the Ajzen & Fishbein theory and examples of possible manipulations of the learning environment in accordance with these adaptations. Explanations of these adaptations and possible manipulations follow the table.

Table VIII

Summary of Adaptations and Possible Manipulations for a Sample Lesson

Elements Joyce & Weil	Aspects Adapted Ajzen & Fishbein	Possible Manipulations
Considerations	The A & F theory used to:	The teacher can:
Instructional Effects (lesson)	a) clarify the concept of attitude toward the subject b) define specific behaviors associated with the lesson	a) be aware of the importance of student work satisfaction b) attempt to promote positive evaluations of work done
Phasing (selection) (organization)	c) suggest how to influence student beliefs to form/change attitude(implicit information) b) consider introducing new related objects which may be evaluated positively	c) select and organize lesson work based on student beliefs about work satisfaction c) introduce new work experience for evaluation
Social System (teacher role)	c) suggest how to influence student beliefs to change attitude by explicit information d) explain how other variables could influence behavior	c) attempt to change beliefs about performing desired behaviors associated with positive attitude toward the subject d) attempt to use the influence of peers to influence beliefs about work satisfaction
Principles of Reaction (teacher responses)	c) suggest how attitude could be made more positive e) suggest how attitude toward the subject(lesson) could be assessed	d) present information about the consequences of behavior during the work of the class e) adjust teaching based on student evaluations of work done in the lesson
Support System (materials)	definition of attitude and its relationship to other variables explain how attitude could be changed assess student attitude	select/organize work which is satisfying present the lesson with the intent of influencing student salient beliefs assess work satisfaction

Intructional Effects

Lesson

The phasing or selection and organization of learning experiences in the lesson is intimately associated with the intended instructional effects. As alluded to earlier, a concominant instructional effect intended for this lesson/unit is to promote positive student attitudes. In the design of the strategy it is assumed that this effect is part of the overall course effect (objective) of promoting positive student attitudes toward Grade 10 science.

Teachers could have many different notions of what a student attitude toward the subject science is. For example it could be a student attitude toward the scientific enterprise, student like or dislike of the subject matter, student opinion, or student feeling toward the subject. The Ajzen and Fishbein theory is used to help clarify for the teacher what their attitudinal objective is. According to this theory, attitude toward the subject science is defined as a learned predisposition of an individual to respond, in a consistently favorable or unfavorable way, to performing behaviors related to the teaching/learning of the subject science. In short the teacher attempts to promote favorable evaluations of behaviors related to the teaching/learning of the lesson/unit/subject. With this definition as a context, the teacher may be better able to focus their teaching to the promotion of positive evaluations of behaviors associated with the puzzle solving lesson. For this lesson the teacher intends to have favorable student evaluations of:

- role playing a scientist
- putting together a portion of a puzzle and recording the observations
- discussing observations with a group of other students and recording their own description of the puzzle
- attempting to identify at least 4 principles of the nature of science suggested

by this activity.

The degree of student work satisfaction is deemed to be an important learning environment variable (related object) which is associated with the evaluation of the attitude object (subject science). Given this association the teacher would intend to have students report they are generally satisfied with the work of the class for that lesson.

The attitudinal instructional effect of this lesson does not exclude other intended effects. For example, this lesson/unit, could also be used by teachers to increase student knowledge about the nature of science and improve upon science process skills.

Phasing

Description

This lesson involves students playing the role of scientists attempting to describe a puzzle of which they are only given portions. They must cooperate and share their description of their portion of puzzle with other groups in the class in order to be able to arrive at a description.

Selection of Activity

Ajzen and Fishbein (1980) stated that the presentation of information (message) is the means by which to change/reinforce belief and subsequently attitude. It was suggested that the information could be implicit, through the manner in which it is presented and or explicit, through the presentation of specific arguments about the consequences of performing/not performing specific behaviors. In terms of adapting the theory, the activity was selected with the intention of providing an implicit message that learning science had positive consequences such as being fun and interesting.

Organization

The overall organization and sequencing of the lesson was partially based on the possible manipulation of the learning environment. The intent of this organization was to structure the lesson in accordance with some student beliefs about what satisfied/disatisfied them. For example, it was inferred from the empirical data that students were more satisfied if there were hands on activities (minimal teacher talk), clear well organized teacher explanations, and positive social interactions. These beliefs were considered in the organization of the lesson. Further, the use of a somewhat novel activity as part of the lesson may introduce a new experience which may be evaluated positively.

Social System

Teacher Role

The teacher's role primarily involves the presentation of the lesson/unit with consideration to the intended instructional effects. In this lesson the teacher, as one effect, could attempt to influence student attitude toward the subject by promoting positive evaluations of behaviors associated with this lesson.

Ajzen & Fishbein provide a framework, or systematic means by which to influence attitude. According to this theory information, both implicit and explicit, is a means by which to influence student beliefs which in turn can influence student attitude toward an attitude object, which in this case is the subject science. As noted earlier the phasing of this lesson represents implicit information that attempts to influence student beliefs about the subject science in a positive way. The theory also states that student beliefs about the subject science could be influenced by the presentation of an explicit message about the consequences of performing/not performing behaviors associated with the teaching/learning of a lesson/unit/subject.

As previously mentioned, it was inferred that some behaviors were viewed more positively than others in terms of student satisfaction with the work of the class. Using this information the teacher can prepare an explicit message which attempts to influence these beliefs. Further, in the case of this study, this information is partially based on some of the empirical findings about which type of behaviors are evaluated more positively. In short, the teacher attempts to influence student attitudes by the presentation of explicit information about the consequences of performing behaviors. A sample of the type of information which could be presented for this lesson is given below:

"Class, today we are going to have the opportunity to solve a puzzle. You are going to be asked to play the role of a scientist who in their work, also try to solve puzzles (problems). Remember, that in this class your active participation in activities such as the one today is very important. Further, 20% of your final mark is based on how well you participate. Try your best to come up with a good description of the puzzle. In addition you will be responsible for knowing both what we did in class today as well as identifying some of the principles of the nature of science we have talked about in class. During this lesson you will also be asked to put together pieces of a portion of a puzzle and record observations of this portion, work with other scientists to arrive at the best possible description of the puzzle, and analyze this activity for some key ideas. These activites could be of use to you. For example observation skills are important in day to day living. These skills help you appreciate your environment and make you more aware of what is happening. Working together with other students is good practice for your future jobs. Most jobs involve you having to work well with other people and being able to communicate your ideas clearly to them. Look at this lesson as a way to improve your social and communication skills. There also exists an opportunity to apply what you have learned in the solving of a problem. Life has many situations that call on you to reason through the situation and come up with a course of action. This lesson does not rely on your ability to memorize facts but upon you figuring out a problem."

The theory also suggests how behavior could be influenced and what teachers could do to influence behavior. For example, according to the theory, peers could influence the behavior of classmates. Because the nature of this lesson and other lessons in the unit is group oriented, there may be greater opportunities for these influences to be exerted in a positive way through careful selection of groups.

Principles of Reaction

Teacher Responses

The teacher, both during and after the lesson/unit can react to what the learner does and how he/she behaves.

The Ajzen & Fishbien theory provides suggestions for how teachers could respond to the learner. One type of response suggested by the theory is the use of feedback for specific behaviors. This feedback could be of the verbal or non-verbal nature. Examples of some possible feedback based on this lesson are:

-" John you have given an excellent description of your portion of the puzzle - please share it with your group"

- Acknowledging smile to a student who has noted a humorous observation

- Awarding a small prize for the best individual description of the puzzle

The purpose of this feedback is to suggest to students that the performance of these desirable behaviors has positive consequences. According to the theory if the consequences are believed to be positive, then there is a greater probability of promoting more positive student attitudes toward similar behaviors in future lessons.

Another response suggested by the theory is to directly communicate the consequences of performing/not performing a desired behavior. For example a teacher may tell a student that their mark for participation has improved as a result of their work during the lesson. This communication is intended to affect student beliefs about performing the behavior. Within the adaptation of the theory and the empirical results the consequences of being satisfied with the activity versus not being satisfied should be a major focus for both verbal and non-verbal interactions during the lesson.

Teachers could also respond to how well the lesson achieved its intended instructional effects. In order to respond, however, the teacher will have to assess if the effects were attained. The result of this assessment could guide the teacher in terms of decisions regarding whether or not to use or modify the lesson/unit. As alluded to earlier, one of the desired effects was to promote more positive student attitude toward behaviors associated with the teaching/learning of the subject science. Further, associated with this effect was to have students satisfied with the work of the class. Another desired effect may be to improve student knowledge about the nature of science.

The Ajzen & Fishbein theory provides a model for the assessment of student attitudes toward the lesson/unit/subject. Using this assessment, which is consistent with the conceptualized description of attitude toward the subject science, it would be possible for the teacher to evaluate how well the lesson met its attitudinal objective. This evaluation could be both informal and formal. In an informal way the teacher can ask students how they evaluate any specific behavior they have been asked to perform. In a formal way teachers could ask students to evaluate the lesson in terms of specific behaviors. For example:

a) My putting together of the puzzle is:

good.........bad

interesting........boring

b) My working with others to find a solution to the puzzle is:

good.........bad

interesting........boring

The scoring of this measure involves the setting of a 5 or 7 point scale for each behavior related to the lesson. The sum of the scale scores should provide an indication of how positively or negatively each behavior was evaluated. Based on these evaluations the teacher should arrive at some notion of how well the lesson attained its attitudinal objective consistent with the Ajzen & Fishbein notion of attitude. This information could also be useful in that it provides meaningful feedback on the quality of the learning experience from a students point of view.

The teacher could also react to how satisfied students were with the work of the class. Specifically the teacher may be able to assess how satisfying the lesson was. For example, he/she could assess the following aspects of satisfaction:

1. Rate on the scale below your feelings about the lesson we had today:

enjoyable__________________ not enjoyable

2a) What aspects of today's lesson were enjoyable ?

2b) What aspects of today's lesson were not enjoyable?

As in the evaluation of specific behaviors, this measure will provide an indication of student work satisfaction and specific information of what aspects were satisfying/not satisfying. Based on this measure teachers may be able to adapt the content or method of presentation of the lesson/unit.

Support Materials

The materials needed for the general principles of the strategy to be implemented are provided in Appendix M. These materials include a teacher's reference as well as an outline of the lessons in the unit. The reference includes an explanation of the intent of the unit and its objectives (instructional effects). With the objectives stated, the materials in the unit are explained in terms of how they could be used by a teacher in order to change student attitudes toward the subject in lieu of adaptations of the Ajzen and Fishbein theory. The outline of activities includes the actual student materials and background information for teachers. In addition to these teaching materials, sample assessment instruments are presented with the intention of providing an indication of how teachers could determine whether or not the lesson/unit achieved its intended instructional effects.

Significance of Strategy

In summary, an attempt at utilizing the general principles of this strategy as illustrated by the sample lesson could make a difference to the approach teachers use to teach. The suggested differences are:

1. an increased awareness about attitudinal objectives and a more precise definition of what an attitude is
2. a more systematic approach which could be used to teach for positive student attitudes congruent with this definition
3. an ability to assess student attitudes in a more meaningful way because it is based on specific behaviors
4. a means to add to the professional development of teachers through the provision of a way to teach which may not be in the teacher's present repertoire

Chapter 5

CONCLUSIONS AND IMPLICATIONS

The purpose of this study was to investigate theoretical and empirical relationships between science classroom learning environment variables and student attitudes toward the subject science and to use these findings interpretively to design a teaching/learning strategy that could be used to improve these attitudes. Possible implications, based on the results of this investigation, for both educational theory and practice will be inferred in this chapter. Moreover, these inferences will be related to previous salient literature and to possible directions for future research in the area of student attitude in science education.

5.1 THEORETICAL CONSIDERATIONS

A theoretical notion of the relationship between student attitude toward the subject science and the science classroom learning environment was described based upon the writings of Haladyna et al. (1982,1983) and Ajzen and Fishbein (1980).

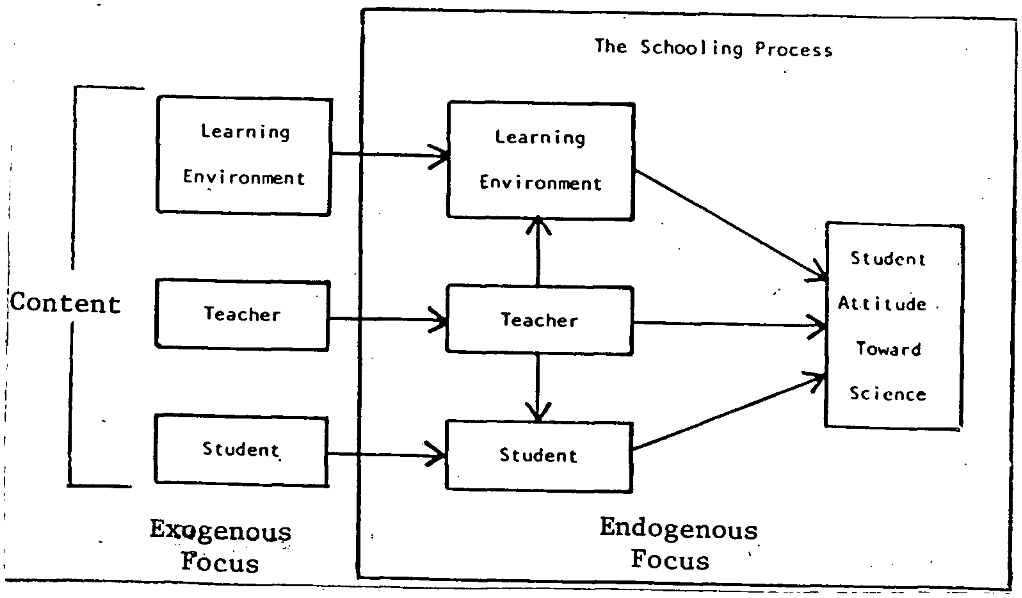
The Haladyna model was utilized to describe general relationships among variables that could influence student attitude toward the subject science. The Ajzen and Fishbein theory was described and analyzed in order to explain how attitudes were acquired, changed, measured, and related to behavior in the teaching/learning of the subject. Moreover, this theory was used to describe the theoretical association between student beliefs about the classroom learning environment to student attitude toward the subject science. Conclusions about the appropriateness and utility of the Ajzen and Fishbein theory and the Haladyna model for educational research follow.

5.1.1 APPROPRIATNESS OF HALADYNA MODEL FOR EDUCATIONAL RESEARCH

The Haladyna et al. (1982,1983) model was utilized to provide an overall perspective on possible variables that influence student attitude toward the subject science. A repeated schematic overview of this model is provided for the readers' convenience in Figure 6.

Figure 6.

Overview of the Haladyna Model



This model appeared to be an appropriate framework to put attitude toward the subject science research in perspective. Moreover, it appeared to consider educationally relevant variables which may influence student attitude. For example, learning environment variables were hypothesized to be important influences of student attitude toward the subject science. In this study the 10 variables of measured student beliefs about the classroom learning environment accounted for 30.8% of the measured variance in attitude toward the subject science. These results would add some support for the validity of this proposed association. Moreover, there were references made by students during the interviews to the significance of learning environment variables such as teacher organization, friendships in the class, and types of activities in terms of how positively the subject was viewed.

If this model was valid for describing relationships among the teacher, learning environment, and student -both within and outside the science classroom- then it would be important for teachers to know which of these variables were significant influences of student attitude toward the subject.

This determination was more complex than the model might suggest. A limitation of the model and the relationships proposed within it, involved the lack of specification of how the learning environment, teacher, student, and subject content interact in the determination of student attitude toward the subject science. Examples of these interactions might have included the influences of the nature of the students on the type of learning environment the teacher would attempt to create or that of teacher personality on the student. Another limitation, given these numerous interactions, is that it may be difficult to develop valid and reliable instrumentation in order to assess them. Finally, there is a need for further investigations into how these variables interact and what effects these interactions have.

The model may also be improved in terms of providing a more complete identification of what specific variables are involved in the exogenous (outside school) and endogenous (inside school) focuses. For example, the question of the importance of specific learning environment considerations outside the school needs further investigation. In this study the influence of outside variables on student attitudes was not considered. It is interesting to note the results of a study done by Hasan (1985), who in a study of factors that influence secondary school attitudes toward the subject science in, found that "involvement in science activities outside the classroom does not seem to have an important influence on their attitudes" (p. 13). In short, there may be a need for further investigations as to what outside variables, if any, influence student attitudes. Given a more specific identification of salient exogenous and endogenous variables, the model may become more precise in terms of the development of a "best model" of predictors. Indeed the work of Haladyna et al. (1983) and the results of this study have made some contributions to this development.

5.1.2 APPROPRIATENESS OF THE AJZEN AND FISHBEIN THEORY FOR EDUCATIONAL RESEARCH

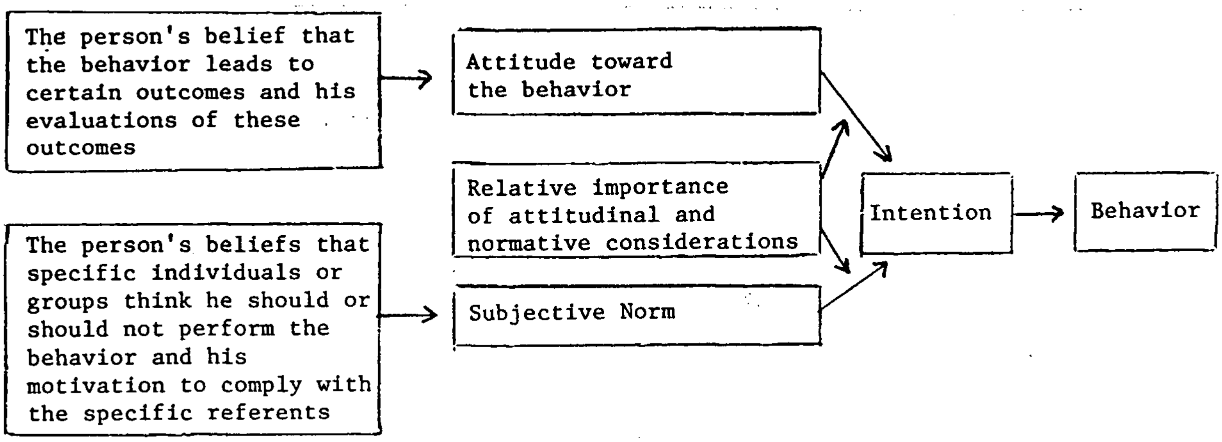
It has been noted that attitude research in science education has often lacked theoretical underpinnings (Koballa & Crawley, 1985; Shrigley, 1983; & Steiner, 1980). Moreover, this lack of theoretical foundations has caused some confusion in terms of the meanings of an attitude and an attitude toward science (Munby, 1980), and the relationship between attitudes to behaviors (Peterson & Carlson, 1979; & Schibeci, 1984). There have been, however, some suggestions for how attitude theory could be applied in research, (Munby et al., 1976; & Shrigley, 1983) but few illustrations of the application of attitude theory in published science education research.

One possible contribution of this study involved the provision of an example of how the Ajzen and Fishbein (1980) attitude theory, from social-psycholological research, was applied in a science education context. Examples of this application included its utilization in the: provision of a perspective on a problem of educational practice, development of an instrument to assess student attitudes, and the design of a teaching/learning strategy to improve student attitudes toward Grade 10 science. These examples of the application of theory to an educational context, may promote other researchers to consider further applications of attitude theory to educational research. These applications were intended to provide a better understanding of how attitude is acquired, changed, measured, and related to behavior. Moreover, a need for this greater understanding has been expressed in previous reports on attitude research in science education (Munby, 1980; Mallinson, 1977; Russell, 1981; & Schibeci, 1984).

The results of this study provided an indication of the appropriateness of the Ajzen and Fishbein (1980) theory for guiding this investigation and perhaps other investigations in an science education context. A schematic overview of the theory is repeated below in Figure 7 in order to review some of its essential propositions.

Figure 7

Overview of the Ajzen and Fishbein Theory



Note: Arrows indicate the direction of influence (from Ajzen & Fishbien, 1980)

The theory, as presented in this study, considered both a delineation of how attitude was operationalized as well as its role in behavioral prediction. The major concern of this study was to utilize the theory to define and measure attitude toward the subject science. It may be sufficient to say that for this study the theory helped delineate, for both research and practical purposes, one perspective of how attitude toward the subject science is acquired and changed as well as providing guidelines for the design of a teaching/learning strategy in an attempt to promote more positive attitudes. The testing of the validity of these associations was not directly addressed because this is more of a concern for attitude theorists such as Ajzen and Fishbein. Further, this theoretical issue of the association between attitude theory and considerations of attitude measures and actual behaviors has been a major focus for social-psychological research (Cooper & Croyle, 1984; Cialdinni et al., 1980; & McGuire, 1985).

Based on some results of this study, however, a few inferences could be made about how well the theory described the association between attitude and behavior. For example, the theory proposed that both attitudinal (personal) and normative (social) considerations were important in terms of the ability to understand and predict behavior. Moreover, it was stated that the relative importance of attitudinal and normative considerations could be predicted through a regression technique. It was found, based on the student interview data, that personal attitudinal considerations were more important than normative ones in terms of understanding student behaviors related to the teaching/learning of Grade 10 science.

During these interviews, students were asked to give an indication of their attitude toward Grade 10 science based upon the perceived beliefs of their friends. Two categories of response, which were salient to the proposals of the theory, were identified. One category involved the uncertainty of what their friends beliefs about Grade 10 science were. This uncertainty was illustrated by responses to the question of whether they believed their friends thought the subject science was good or bad. The most common response was that they didn't know what their friends beliefs were because they didn't really talk about the science course. A second category of response noted was the need for students to identify their salient referent group, which in the theory, was proposed as a factor that influenced student intentions to perform a behavior. In three questions which alluded to the influence of friends on their attitude toward the subject, 17 out of 36 categorized responses indicated that students had difficulty in identifying what their friends beliefs were because they varied from friend to friend.

The lack of knowlegde about what their friends perceptions were and the need for the specification of a salient referent group have some implications in terms of using the Ajzen and Fishbein perspective for better understanding behavior in educational settings. One implication involved the relative importance of the influence of normative considerations on understanding the relationship between attitude and behavior. Because of the apparent lack of reported communication within the normative group about the consequences of performing behaviors, the influence of these normative considerations may not be as important as the theory suggested. However, it was interesting to note the findings of Talton and Simpson (1985), who in an investigation of peer influence on student attitudes toward the subject science in Grades 6 to 10, concluded "the relationship of peer influence with science attitude among adolescents is significant" (p. 22). Moreover, these authors reported that not much research has been done in the area of peer influence on student attitudes. Given this report and the findings of this study, it would appear that this problem deserves further research.

Another implication, based on the difficulty students encountered in generalizing their friends perceptions, involved the support given to the theory which held that in order to determine the social norm one must specifically identify the salient referent group. If this group is not identified, as was the case in this study, the influence of the social normative group is difficult to assess.

5.2 EMPIRICAL CONSIDERATIONS

As alluded to earlier, the second line of investigation was concerned with a determination of the nature and strength of the empirical relationship between classroom learning environment variables and student attitude toward Grade 10 science. As a result of this investigation some possible implications for educational research and practice in the areas of teaching ideas, measurement, and research methods are suggested.

5.2.1 TEACHING IDEAS

The empirical results were interpreted in terms of possible adaptations or ideas Grade 10 science teachers may consider in an attempt to improve the science classroom learning environment or student attitudes. These adaptations and ideas related to the questions of: a) What classroom learning environment variables were empirically related to student attitude toward Grade 10 science? b) What science activities did students view positively or negatively? c) How did students view their science classroom learning environments? and d) What suggestions did Grade 10 science teachers and students have for improving student attitudes toward the subject science?

Satisfaction

According to the regression analysis the most significant learning environment variable, in terms of influencing student attitude toward Grade 10 science, was student belief about Satisfaction. This variable, was described as the extent to which students were satisfied with the work of the class.

This finding of a relationship, however, is not as significant to practice as the questions of: What specific activities satisfy or disatisfy students? and What can science teachers do to promote greater satisfaction with the subject? Some possible answers to these questions were inferred from the results of both assessments of student attitude on the ATSSS and interviews of teachers and students.

The ATSSS results provided an overall indication of both student attitude toward Grade 10 science and toward specific activities related to the subject. The mean attitude score was 201.1, which if interpreted literally, suggest that overall student attitudes toward the subject were neutral. Moreover, these results also suggested there may be room for the improvement of these attitudes.

The results of the total scores on the ATSSS were not as significant for practice as the analysis of individual item scores on this instrument. These items were concerned with measuring student attitudes toward behaviors related to the activities of a typical Grade 10 science classroom. The most positive student attitudes, in order of significance, were towards: actively participating in lab activities, watching science related televison programs, trying to achieve good science marks, and trying to keep a good science notebook. The most negatively viewed activities, in order of significance were: reading the science text at least once a week, trying science experiments at home, and listening to the teacher talk about science. Based on these findings, if science educators desired to improve their student's attitudes toward the subject, they might be able to consider strategies which emphasize those activities that were viewed more positively and minimize those which were viewed negatively.

The question of what science activities were viewed positively and negatively was also addressed in the student interviews. In terms of the activities which were viewed positively, the most common response was doing hands on activities/science labs/working with equipment. Moreover, when students were asked about what they would do, if they were a science teacher, to promote positive student attitudes toward the subject, the most common response was to have more labs/experiments/hands on activities. In addition to this supporting evidence of a relationship, teachers, in their suggestions for how to improve student attitudes, ranked the involvement of students in activities as the second most important. The ATSSS, the interview results, and the teacher suggestions provided strong support for the relationship between positive student attitudes and active participation in the science class.

The data revealed other factors which may have promoted satisfaction or disatisfaction with the science classroom learning environment. The second most important factor revealed in the interview data, in terms of what students liked/disliked in their classes, was clear well organized teacher explanations. This finding is particularly salient to practice because teachers reported the Disorganization variable as the most controllable in a classroom situation. If this variable is as controllable as the data suggested, then it should be one teachers can manipulate or attempt to change in order to improve student attitudes.

Given the importance and controllability of the organization of a science class, it should be noted that students viewed negatively too much teacher talk in the instruction of science. Moreover, in the ATSSS assessment, teacher talk was the second least favored activity. Further in the interview data, too much teacher talk was viewed as the activity most disliked. Five out of sixteen students reported that listening to the teacher talk all class was boring. These findings suggest that teachers might attempt short, clear, well organized explanations rather than overly detailed, drawn out, wordy discourses.

The data also suggested other organizational influences on student attitude. One of these influences was the degree of teacher control on activities of the class. In the student interviews 4 out of 16 students stated that they expected more teacher control of the class and less student talk. One possible implication of this finding for practice is that students expect rules and discipline in class in which the teacher is in control.

In addition to the activity and organizational dimensions, there were other variables which, based on the data, could have influenced student satisfaction or disatisfaction with the subject. One of these variables, which was suggested in the teacher and student interviews, was the personal relationship between the teacher and their students. The teacher as a person was mentioned as a variable that influenced student attitudes. Moreover, of particular significance, were the student responses to the question of how they would promote more positive attitudes toward the subject in a science classrooom they taught. Three of the nine categorized responses were concerned with how they as teachers would emphasize the personal aspects of the class. In this emphasis they said they would try to get along, have fun, and share experiences with their students. Emphasizing good personal relationships was also mentioned by teachers as one way which could be used in order to promote more positive student attitudes. This finding of the importance of teacher-student personal relationships has also been found to be important in terms of what teachers perceived to be "good teaching" (Bybee, 1978) and a positive classroom learning environment (Cooper & Petrofsky, 1974). The question which arises from these findings is one of what can be done at the instructional level to improve these relationships ?

Apathy

Apathy was revealed as the second best learning environment predictor of student attitude toward the subject science. This variable was described as the extent to which students cared about their class. As in the case of student satisfaction it was relevant to determine what it was in the teaching and learning of science that would help students care more about the subject. Based on the results of the study, a few inferences will be made as to how student apathy may be decreased and student attitudes toward the subject improved.

A major factor which could be related to the extent to which students care about the subject was the degree to which science content was perceived to be related to real life or to be useful and relevant. In the interview of students 6 out of 16 categorized responses to the question of why students viewed the subject as good/bad were concerned with the perceived relationship between science content and life outside of school. Moreover, statements for the importance of having this relationship were also given by student responses to the question of what they as science teachers would do to improve their own students attitudes toward the subject.

In addition to the call for relevance there may also be a relationship between the perceived usefulness of the subject to the extent to which students care about the class. The most common response to the question of why Grade 10 science was useful/useless was to do with future career/schooling plans of the students. Moreover, in the question of their friends beliefs about the usefulness of Grade 10 science , 9 out of 11 responses were concerned with future career/schooling options. A possible implication for practice is that if teachers can provide more information about careers/future schooling options which are related to the science content they may be able to improve student caring and attitude.

The assessment of attitude by the ATSSS also suggested other factors which may be considered as important in decreasing student apathy. In this assessment, students viewed positively trying to get the best mark they could and trying to keep a good science notebook. The implication for teachers is that if they can provide further motivations for students caring about the mark they get or the way they keep their books, then it may help promote a greater sense of caring about the class and a more positive attitude toward the subject.

Teachers also provided some suggestions in the interviews about what teaching strategies could be incorporated in an attempt to improve student attitudes and decrease student Apathy. The most common suggestion was to have an emphasis on the practical/social/personal aspects of science content in the presentations and activities of the science class. This suggestion, however, creates a concern for science teachers, education officials, and curriculum planners. This concern, which was alluded to by three teachers from the sample, involved the need for greater teacher knowledge about these applications. Further to this concern, teachers may need more support from their curriculum committees for the development of short information and activity lessons which highlight how specific science content can be applied in daily living. A concrete example of one area which needed this support was the chemistry section of the Grade 10 program in the Province of British Columbia. The student interview data revealed comments about how there was a lack of understanding about how chemistry applied to life. It would seem possible to have district or provincial organizations produce such resource materials.

Another teacher suggestion for improving student attitudes toward the subject may also be related to decreasing student apathy toward their science class. This suggestion entailed the value of showing a high degree of teacher enthusiasm for the subject science. This enthusiasm could be directed towards promoting the value of learning about science to both students and society in general. If this image can be projected, there may be a transfer of some of this enthusiasm for the subject to the students. It is interesting to note that Yager and Penick (1984) found, in a study of what high school students had to say about science teachers and science teaching, that science teachers were perceived to be enthusiastic and liking science.

Difficulty

A third variable, student belief about the difficulty of the class, was also revealed in the regression analysis to be related to the measure of student attitude toward Grade 10 science. This variable was described as the extent to which students found the work of Grade 10 science as relatively difficult. Moreover, the LEI data revealed that students viewed the subject as difficult.

The interview data revealed some specific concerns about why science was viewed as a difficult subject. Some of these concerns were: problems with mathematics, formulas, and memorization. The problem with mathematics and formulas has been documented in previous science education literature (Ormerod & Duckworth, 1975). This problem is not an easy one with which to deal in the practical situation of the science classroom teacher. Orpwood (1976) believed that there are many curricular implications which result from the perception that science is a difficult subject. This concern of having an appropriate difficulty for the wide diversity of abilities, interests, and background is relevant to both curriculum developers and teachers. It would appear, based on the results of this study, that teachers might have to be more flexible in terms of adjusting the difficulty of curricular materials.

5.2.2 SPECULATION ABOUT THE REMAINING VARIANCE

This study suggested that learning environment variables were a factor in terms of influencing student attitude toward the subject science. As alluded to earlier, approximately 30% of the variance in attitude score was accounted for by these variables. This figure compares quite favorably with that of Hasan (1985) who was able to account for only 6.3% of the variance based on student motivational, instructional and outside cultural variables.

Haladyna et al. (1983) identified many possible influences of student attitude toward the subject science. This identification was based on both an analysis of teaching practice and research results. Based on the review of literature, it appears that this model has identified the important variables such as the learning environment, the teacher, and the student both inside and outside of the school setting. In the writer's opinion the search for other sources of variance may not prove as fruitful as the search for a greater understanding of the variables which have already been identified.

The writer would also like to suggest that within these variables the focus of research should be on variables teachers may be able to do something about. For example, perhaps the five variables which were reported as not controllable could have accounted for variance in attitude score. Moreover, perhaps student gender or socio-economic status of parents could also have been important. The issue here is that if gender or economic well being were factors, teachers could do very little to alter these variables. Further, as reported earlier studies which have focussed on multitudes of variables have not produced consistent or fruitful information to help improve teaching practice. In short, the question of where the rest of the variance is may not be as important as questions about how teachers can improve attitudes of females or of students who come from lower socio-economic groups.

The researcher would however like to speculate on some variables which may account for some of the variance. Two learning environment variables which may be important are Clarity of Instruction and Teacher Discipline. This speculation is based on some of the interview findings. An aside to this speculation could involve the need to identify more precisely the teacher characteristics or types of classrooms which promote positive attitudes. Other possible sources which could be investigated, based on the theoretical notion of attitude utilized in this study, are the influence of peers on attitude and behavior and the role of student preconceived notions (beliefs) about the subject science.

5.2.3 MEASUREMENT IMPLICATIONS

The development and hopefully, the subsequent use of the ATSSS may make contributions to science education research and practice. Moreover, the further use and development of this instrument would be desirable given the calls for an attitude instrument which is based upon theoretical foundations (Messick, 1975; Koballa & Crawley; 1985, & Steiner, 1980). The ATSSS, was based on the Ajzen and Fishbein theory. Moreover, this theory has been suggested as a possible appropriate foundation to guide attitude research in science education (Hartman, 1972; Shrigley, 1983; & Zeidler, 1984).

There is a need, however, for further evaluation and testing of both the psychometric and theoretical foundations of the ATSSS. For example, there may be other behaviors, which were not identified in the ATSSS, which may be salient to the teaching and learning of Grade 10 science. These behaviors can form the basis for other items on the instrument. This testing and evaluation of one instrument based on a particular framework, as Gauld and Hukins (1980) suggested, may be better than the development of many instruments intended for the same purpose.

The nature of the ATSSS, given its specificity of identification of behaviors related to the teaching and learning of science, provided useful information to science teachers about both their class and their teaching. Moreover, this information was received positively by the teachers who participated in this study. Furthemore, because this instrument is easy to administer, it can be utilized by science classroom teachers in order to obtain feedback on how students view the class and the subject science. This feedback may assist teachers in the evaluation of how well the science course is achieving its attitudinal objectives.

A major problem, in terms of promoting further use and development of an attitude instrument is publicizing its existence (Klopfer, 1983; & Munby, 1980). Steps have been taken, however, to make the ATSSS available for use in the British Columbia School system. These steps have included the presentation of reports to the Ministry of Education Curriculum Department, the Science and Technology 11 Curriculum Committee, and the Kamloops School District science teachers. Moreover, there was a presentation by this author on the possible uses of the ATSSS at Science Spectrum 85 at the University of British Columbia. The ATSSS has also been made available for dissemination through both the Educational Research Institute of British Columbia, ERIBC, and the ERIC Clearing House (Krynowsky, 1985). Moreover, articles on the development of the instrument have also been submitted. Hopefully this promotion will make some contribution to development of valid and reliable instruments to measure the construct attitude toward the subject science.

The other major measurement concern in this study involved the assessment of student beliefs about the science classroom learning environment. The LEI was used for these assessments. Moreover, this instrument has been the most widely used one for this purpose (Chavez, 1984). It was assumed that this instrument, based on the previous data available, was valid and reliable for this purpose. Moreover, further analysis of the instrument, given in Table XI, provided support for this assumption. However, there may be a need for both minor revisions to some of the wording within the 10 scales which were used for this study and the addition of other salient scales. In terms of the wording there were a few words that Grade 10 students had difficulty understanding. The most common words were: democratically, and aptitude. Moreover, the phrasing of four items was awkward and created confusion for some students.

The interview data indicated a possible need for additional scales in this instrument in order to better capture the essence of a classroom learning environment. These possible scales, were: Discipline, Activity, and Clarity. Given the selection of scales from the LEI, the researcher would advocate a more careful selection of scales to suit the purposes of the research.

In addition to the LEI, there may be further consideration given to other instruments which may be used in classroom learning environment research. A possibly useful instrument, which requires further development and testing, is the one developed by Skirotnik and used by Goodlad in his study of schooling which was summarized in the book A Place Called School (1984). This instrument, which was based on the two most widely used instruments in learning environment research, the Learning Environment Inventory and the Classroom Environment Scale, may provide a more complete description and analysis of a classroom learning environment. This information can be valuable in terms of teacher formative evaluations. Moreover, these evaluations can be used by teachers to direct their energies toward promoting a more positive science classroom learning environment and perhaps more positive student attitudes.

5.2.4 RESEARCH METHODS

The results of the empirical line of investigation may have some implications for improving research methods in the area of student attitudes. Some of these implications have been alluded to in previous discussions. However, a few additional specific implications are presently discussed.

The regression analysis used in this study identified which measures of student belief about the classroom learning environment were related to a measure of student attitude toward Grade 10 science. However, the question of the educational implications of these identifications, in the researcher's view, was of greater significance. Moreover, the question of how the variables of Satisfaction, Apathy, and Difficulty can be manipulated in order to improve student attitudes was also one of practical significance. In retrospect, it was possible to follow up these findings of important variables through the use of an interview technique. This follow up was valuable in terms of finding out more specific information about how these variables could be manipulated in a teaching situation. For example, the identification of the Satisfaction variable as a significant influence was not as meaningful as the investigation into what it is in the teaching and learning of science that satisfies or disatisfies students.

The identification of important variables, with techniques such as a regression or path analysis, are a preliminary step on the road to improving practice. An interview technique, given its limitations and possible bias, was a valuable one for drawing inferences regarding possible teaching strategies that could be used to improve student attitudes. Moreover, these interview results were well received and understood by teachers and administrators involved in this study. If teachers can understand research results, there is likely a greater probability that educational research can make a difference to educational practice.

In terms of how interviews could be used more effectively in attitudinal research in science education, there may be other alternatives to the method used in this study. The results of the regression analysis were not known prior to the development of the interview schedule. Another possible method, which may have been more effective, entails the identification of salient variables as a starting point for the development of either an interview schedule or intervention program. The interview or intervention may then proceed with a more detailed focus on how or why those variables were related to student attitudes toward the subject science.

Another consideration in terms of possible implications for improving research methods involved the need for crossvalidation of the empirical findings of this study. In terms of the variables which were found to be significant, it would be desirable to replicate this study with another sample in order to determine if the empirical results were similar. It would also be desirable to determine if a congruency existed between student self reported attitude and behavior through researcher or teacher observations of students in a classroom situation. It should be noted, however, that the empirical results were primarily utilized to provide an example of how a theoretical notion of attitude and attitude change could be applied in the context of designing a teaching/learning strategy.

The area of learning environment-attitude relationships has other possibilities for future research designs. One of these possibilities could involve the search for what both students and teachers would consider to be an ideal learning environment for promoting positive student attitudes toward the subject science. This area was addressed superficially in the interview dimension of this study. However, this question deserves a more detailed investigation.

If research can clarify what the desired and important classroom variables are, then it may be appropriate to attempt specific interventions into the classroom to determine if they make a difference in terms of student attitudes. For example, if student perceived difficulty of science, which in this study, included considerations such as the abstractness of chemistry or the overabudance of required memorized formulas, was found to an important factor, then specific materials or methods can be attempted to moderate the perception that science is too hard.

Finally, there may be a need to provide further evidence to substantiate claims made about the value of positive student attitudes toward the subject science. Science educators have argued that associations exist between these attitudes and future science learning (Mager, 1968), science hobbies and interests (Payne, 1977), science related careers (Hasan, 1975; & Gardner, 1976) and generally more scientifically literate citizens (Ayers & Price, 1975; Payne, 1977; & Wareing, 1982). However, empirical data to substantiate these claims were not found by the researcher. This lack of support would suggest that there is a need for further longtitudinal research to determine if these claimed associations exist. Moreover, this determination is important in terms of implications it may have for curriculum planners and science teachers. For example, if student attitudes were not found to be as important in future adult life as has been suggested, then attitudinal goals may not deserve the emphasis they have received in both the outlined curriculums or the time spent in teaching for these goals.

5.3 DESIGN OF TEACHING/LEARNING STRATEGY

The design of a teaching/learning strategy was undertaken with the intention of illustrating how a theoretical notion of attitude and attitude change could be followed through to address a problem of practice - mainly what are some ways Grade 10 science teachers could use to improve student attitudes toward their subject. The steps leading to this design included the description of the Ajzen and Fishbein view of attitude, the application of this view to a science education context, and the description of a theoretical notion of how student beliefs about the classroom learning environment could be related to student attitude toward the subject science. Key aspects of this notion along with some empirical relationships identified in this study, were applied to educational practice by adapting elements of a strategy suggested by Joyce and Weil (1980).

This following through of a theoretical notion to the science classroom with an actual design of a strategy is a significant contribution to attitude toward the subject science research and science education practice. The significance is found in that there have been numerous statements in the literature for the need for theoretical foundations to guide research efforts in the area. The contribution then, is an extension of the work done by Joyce (1978) and Joyce and Weil (1980), in that the design allowed for the

> selecting and creating opportunities for learning experiences, and on a particular way of making available to teachers these products of theory and research that can enrich both the thinking and acting dimensions of teaching (Joyce, 1978, p. 1)

More specifically, the interpretation of the theoretical and empirical results of this study in order to design this strategy made contributions because it provided:

- an example of how a theoretical view of attitude change could be applied to the teaching for positive student attitudes

- specifications for how a unit could be planned with the objective of improving student attitudes

- resources and ideas which could be adapted by teachers in their own situation

The primary goal then for the design was to provide ideas for Grade 10 science teachers, not only to address the concern of how student attitudes could be improved, but also to provide an example of an approach which could be used to expand upon the strategies they presently use. This expanding of strategies is a step along the road to further personal and professional development. These improvements may be possible because general principles of the design could be applied for other units of instruction or for other grade levels.

One might suggest, however, that the design should be tested experimentally in order to ascertain whether or not it made a difference in student attitudes toward Grade 10 science. It would be possible, with a few more specifications for instruction, to experimentally test for the effects of the the strategy. This study, however, was not intended to test treatment effects of any particular strategy. The intention was to address problems noted in the literature with regard to greatest needs in the area of attitude toward the subject science research. Specifically, the needs which were addressed were to: outline and use an established theoretical notion of attitude for the purpose of identifying a possible framework for guiding future attitude toward science research; to collect more information on the empirical relationship between classroom learning environment variables and student attitude toward the subject science; and finally to illustrate an example of how theory could be adapted to address a problem of educational practice. This is not to say that there is no need for further testing and revision of the design. Nor does it say that it is not possible to do this testing in future research. The point here is that the testing of experimental treatments was not the focus of this study.

5.4 CONCLUDING COMMENTS

In conclusion, this study attempted to provide some answers to an important question for science educators, namely, how can positive student attitudes toward Grade 10 science be promoted in a classroom teaching situation. Hopefully, more positive attitudes will encourage students, who leave Grade 10, to further pursue learning about science and technology in their future schooling and adult lives.

REFERENCES

Abraham, M.R., Renner, J.W., Grant, R.M., & Westbrook, S.L. (1982). Priorities for research in science education: a survey. Science Education, 19(8), 697-704.

Anderson, C.S. (1982). The search for school climate. Review of Educational Research, 52(3), 368-420.

Anderson, E.J., & Herrera, D.B. (1976). Development of a scientific attitude scale for spanish speaking populations. Journal of Research in Science Education, 13(1), 45-48.

Anderson, G.J. (1970). Effects of classroom social climate on individual learnings. American Educational Research Journal, 7, 135-152.

Anderson, G.J. (1971). The assessment of learning environments: a manual for the learning environment inventory and the my class inventory . Halifax: Institute of Education.

Anderson, G.J., & Walberg, H.J. (1974) Learning environments, In H.J. Walberg (Ed.) Evaluating educational performance: a sourcebook of methods, instruments, and examples. Berkeley: McCutchan.

Anderson, G.J., & Walberg, H.J. (1974). Assessing classroom learning environment. In K. Marjoribanks (Ed.), Environments for learning, Slough: NFER.

Anderson, G.J., & Walberg, H.J. (1976). The assessment of learning environments: A manual for the learning environment inventory and the my class inventory. Chicago: University of Illinois.,

Aiken, L.F., & Aiken, D.A. (1969). Recent research on attitudes concerning science. Science Education, 53(4), 295-305.

Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behaviour. Englewood Cliffs, NJ: Prentice-Hall.

Ato, T., & Wilkinson, W.J. (1982). New hull scales for the measurement of attitudes to science. School Science Review, 63, 559-560.

Ayers, J.B., & Price, C.O. (1975). Children's attitudes toward science. School Science and Mathematics, 75(4), 311-318.

Billeh, V.Y. & Zachariades, G.A. (1975). The development and application of a scale for measuring scientific attitudes. Science Education, 59(2), 155-165.

Birnie, H.H. (1978). Identifying affective goals in science education. The Science Teacher, 45(9), 29-34.

Bloom, B.S. (1971). Affective consequences of school achievement. In J. Block (Ed.), Mastery learning. New York: Holt, Rhinehart, Winston.

Boulanger, F.D. (1981). Ability and science learning: a quantitative synthesis. Journal of Research in Science Teaching, 13(2), 113-121.

Bratt, M.H. (1977). An investigation of two methods of science instruction and teacher attitudes towards science. Journal of Research in Science Teaching, 14(6), 533-538.

Bratt, M.H. (1984). Further comment on the validity studies of attitude measures in science education. Journal of Research in Science Teaching, 21(9), 951-952.

British Columbia Science Assessment (1979). General Report. Victoria: Province of British Columbia, Ministry of Education.

British Columbia Science Assessment (1982). General Report. H. Taylor (Ed.). Victoria: Province of British Columbia, Ministry of Education.

Bullard, J., Cloutier, F., Gore, G. , Madhosingh, C., Gurney, B., & Millet, G. (1984). Science Probe. Toronto: John Wiley & Sons.

Butts, D.P. (1983). The survey- a research strategy rediscovered. Journal of Research in Science Teaching, 20(3), 187-193.

Bybee, R.W. (1978). Science educators' perceptions of the ideal science teacher. School Science and Mathematics, 78(1), 13-22.

Bybee, R., Harms, N., Ward, B., & Yager, R. (1980). Science, society and science education. Science Education, 64(3), 377-395.

Champlin, R.F. (1972). The development and field testing of an instrument to assess student beliefs about and attitudes toward science and scientists. Dissertation Abstracts International, 31, 4574A.

Chavez, R.C. (1984). The use of high inference measures to study classroom climates: a review. Review of Educational Research,. 54, 237-261.

Comber, L.C, & Keeves, J.P. (1973). Science education in nineteen countries. New York: John Wiley.

Cooper, C., & Cooper, R. (1976). Clasroom climate-assessing highs and lows. The Science Teacher, 43(1), 17-20.

Cooper, J., & Croyle, R. (1984). Attitudes and attitude change. Annual Review of Psychology, , 35, 395-496.

Cooper, C. & Petrosky, A. (1974). High school students perceptions' of science teachers and science classes. Science Teacher, 41(1), 22-26.

DeYong, A.J. (1977). Classroom climate and class success: a case study at the university level. Journal of Educational Research, 70(5), 252-257.

Diederich, P.B. (1967). Components of the scientific attitude. Science Teacher, 34(2), 23-24.

Doob, L.W. (1947). The behavior of attitudes. Psychological Review , 54, 135-136.

Doran, R.L. (1980). Basic measurement and evaluation of science instruction. Washington: National Science Teachers Association.

Doran, R.L., Guerin, R., & Cavalieri, J. (1974). An analysis of several instruments measuring 'nature of science objectives'. Science Education, 58(3), 321-329.

Duckworth, D. (1970). The swing from science. Educational Science, 40, 19-21.

Dutton, W., & Stevens, L. (1963). Measuring attitudes toward science. School Science and Mathematics, 63(1), 43-49.

Eisenhardt, E.B. (1977). A search for the predominant causl sequence in the interrelationships of interest in academic subjects and academic achievemnt: a cross-lagged panel correlation study. Dissertation Abstracts International, 37422SA.

Eggen, P. (1978). The prediction of science student attitudes from their nonverbal behavior. Journal of Research in Science Teaching, , 15(6), 523-526.

Erickson, G.L., & Erickson, L.J. (1984). Females and science achievement: evidence, explanations and insights. Science Education, 68(2), 63-89.

Festinger, L.A. (1957). A theory of cognitive dissonance. Stanford Universtiy: Stanford University Press.

Fishbein, M.A. (1967). Readings in attitude theory and measurement. M. Fishbein (Ed.), New York: John Wiley.

Fishbein, M.A., & Ajzen, I. (1975). Belief attitude intention and behavior: an introduction to theory and research. Reading, Mass.: Addison Wesley.

Fisher, R.J. (1982). Social psychology: an applied approach. New York: St Martin Press.

Fisher, D.L., & Fraser, B.J. (1981). Validity and use of the my class inventory. Science Education, 65(2), 145-156.

Fisher, D.L., & Fraser, B.J. (1983). A comparison of actual and preffered classroom environments as perceived by science teachers and students. Journal of Research in Science Teaching , 20(1), 55-61.

Fisher, T.H. (1969). The development of an attitude survey for junior high science. School Science and Mathematics, 69, 647-652.

Fraser, B.J. (1977). Selection and validation of attitude scales for curriculum evaluation. Science Education, 61(3), 317-329.

Fraser, B.J. (1978a). Some attitude scales for ninth grade science. School Science and Mathematics, 78(5), 379-383.

Fraser, B.J. (1978b). Environmental factors affecting attitude toward different sources of scientific information. Journal of Research in Science Teaching, 15(6), 491-497.

Fraser, B.J. (1978c). Measuring learning environment in individualized junior high school classrooms. Science Education, 62(2), 125-133.

Fraser, B.J. (1978d). Use of content analysis in examining changes in science education over time. Science Education, 62(3),317-329.

Fraser, B.J. (1979). Evaluation of a science-based curriculum. In H.J. Walberg (Ed.), Educational environments and effects: evaluation, policy, and productivity. Berkeley: McCutchan.

Fraser, B.J. (1980). Guest editor's introduction: research on classroom learning environment in the 1970's and 1980's. Studies in Educational Evaluation, 6, 221-223.

Fraser, B.J. (1981a) Using environmental assessments to make better classrooms. Journal of Curriculum Studies 13(2), 131-144.

Fraser, B.J. (1981b). Predictive validity of an individualized classroom environment questionnaire. Alberta Journal of Educational Research, 27(3), 240-251.

Fraser, B.J. (1982). How strongly are attitude and achievement related? School Science Review, 63, 557-559.

Fraser, B.J., Anderson, G.J, & Walberg, H.J. (1982). Assessment of learning environments: manual for learning environment inventory (LEI) and the my class inventory(MCI) (3rd ed.). Perth Australia : Western Australian Institutue of Technology.

Fraser, B.J. & Butts, W.L. (1982). Relationship between perceived levels of classroom individualization and science related attitudes. Journal of Research in Science Teaching, 19(2),143-154.

Fraser, B.J. & Fisher, D.L. (1983). Development and validation of short forms of some instruments measuring student perceptions of actual and preferred classroom learning environment. Science Education, 67(2), 115-131.

Fraser, B.J., & Rentoul, A.J. (1983). Person-environment fit in open classrooms. Journal of Educational Research, 73, 159-167.

Fraser, B.J., & Walberg, H.J. (1981). Psychosocial learning environment in science classroom: A review of research. Studies in Science Education, 8, 67-92.

Gabel, D.L., Rubba, P.A., & Franz, J.R. (1977). The effect of early teaching and training experience on physics achievement, attitude toward science teaching, and process skill proficiency. Science Education, 64(4), 503-511.

Gardner, P.L. (1976). Attitudes toward physics: Personal and environmental influences. Journal of Research in Science Teaching, 13(3), 111-125.

Gardner, P.L. (1975a). Attitudes to science: a review. Studies in Science Education, 2, 1-41.

Gardner, P.L. (1975b) Attitude measurement: a critique of some recent research. Education Research, 17(2), 101-109.

Gauld, C.F. (1982). The scientific attitude and science education: a critical reappraisal. Science Education, 66, 109-121.

Gauld, C.F., & Hukins, A.A. (1980). Scientific attitude: a review. Studies in Science Education, 7, 129-161.

Geisert, P. (1977). The coercive use of affective objectives. Science Education, 61(2), 253-257.

Getzels, J.W., & Thelen, H.A. (1960). The classroom as a unique social system. National Society for the Study of Education Yearbook, , 59, 53-81.

Glass, G.V. (1976). Primary, secondary, and meta-analysis of research. Educational Researcher, 5, 3-8.

Goodlad, J.I. (1984). A place called school: prospects for the future. New York: McGraw Hill.

Hadden, R.A., & Johnstone, A.H. (1982). Primary school pupils' attitudes to science: the year of erosion. European Journal of Science Education, 4, 397-407.

Hadden, R.A., & Johnstone, A.H. (1983). Secondary school pupils' attitudes to science: the years of formation. European Journal of Science Education, 5, 309-318.

Haertel, G.D., Walberg, H.J., & Haertel, E.H. (1981). Sociopsychological environments and learning: a quantitative synthesis. British Educational Research Journal, 7, 27-36.

Haertel, G.D., Walberg, H.J., & Weinstein, T. (1983). Psychological models of educational performance: a theoretical synthesis of constructs. Review of Educational Research, 53(1), 74-91.

Haladyna, T., & Shaughnessy, J. (1982). Attitudes towards science: a quantitative synthesis. Science Education, 66(4), 547-563.

Haladyna, T., Olsen, R., & Shaughnessy, J. (1983). Correlates of class attitude toward science. Journal of Research in Science Teaching , 20(4), 311-324.

Haladyna, T., Olsen, R., & Shaughnessy, J. (1982). Relations of student, teacher and learning environment variables to attitudes to science. Science Education, 66(5), 671-687.

Haladyna, T., & Thomas, G. (1979). The attitudes of elementary school children toward school and subject matters. Journal of Experimental Education, 48(1), 18-23.

Hamilton, D.A. (1982). Jamaican students' attitude to science as it relates to achievement in external examinations. Science Education, , 66(2) , 155-169.

Haney, R.E. (1964). The development of scientific attitudes. Science Teacher, 31(1), 33-35.

Hansen, R. (1977). Attitude goals in secondary school sciences. Journal of Research in Science Teaching, 14(6), 579-580.

Hartman, D.D. (1972). The determination of the applicability of the Fishbein model of attitudes in ascertaining the attitudes toward science held by high school science students. Unpublished doctoral dissertation, University of Wisconsin.

Hasan, O.E. (1975). An investigation into factors affecting science interest of secondary school students. Journal of Research in Science Teaching, 12(3), 255-261.

Hasan, O.E. (1985). An investigation into factors affecting attitudes toward science of secondary school students in jordan. Science Education, 69(1) , 3-18.

Hasan, O.E., & Billeh, V.Y. (1975). Relationship between teachers' change in attitudes toward science and some professional variables. Journal of Research in Science Teaching, 12(3), 255-261.

Haukoos, G.D., & Penick, J.E. (1983) The influence of classroom climate on science process and content achievement of community college students. Journal of Research in Science Teaching, 20 (7), 629-637.

Herron, J.D., & Wheatley, G. (1974). A working theory of instruction. Science Education, 58(4), 509-517.

Hodson, D., & Freeman, P. (1983). The effect of primary interest in science: some research problems. Research in Science and Technological Education, 1, 109-118.

Hofstein, A., Gluzman, R., Ben-Zvi, R., & Kempa, R.F. (1977). A factor analytic investigation of Meyer's test of interests. Journal of Research in Science Teaching, 14(1), 63-68.

Hofstein, A., Gulzman, R., Ben-Zvi, R., & Samuel, D. (1979). Classroom learning environment and student attitudes towards chemistry. Studies in Educational Evaluation, 5(3), 231-236.

Hofstein, A., Gluzman, R., Ben-Zvi, R., & Samuel, D. (1980). A comparative study of chemistry students' perceptions of the learning environment in high schools and vocational schools. Jouranl of Research in Science Teaching, 17(6), 547-552.

Hofstein, A., Yager, R.E., & Walberg, H.J. (1982). Using the science classroom learning enviornment for improving instruction. School Science and Mathematics, 82, 343-350.

Hough, L.W., & Piper, M.K. (1982). The relationship between attitudes toward science and science achievement. Journal of Research in Science Education, 19(1), 33-38.

Hovland, C.I., & Rosenberg, M.J. (1960). Attitude organization and change. New Haven, Conn.: Yale University Press.

Hull, C.L. (1943) Principles of Behavior. New York: Appleton.

Junior Secondary Science Curriculum Güide. (1983). Victoria: BC. Ministry of Education, Province of British Columbia.

Johnson, R.T. (1981). Children's attitudes toward science. Science and Children, 18(5), 39-41.

Johnson, R.T., Ryan, F.L., & Schroeder, H. (1974). Inquiry and the development of positive attitudes. Science Education, 58(1), 51-56.

Jones, B., & Butts, D. (1983). Development of a set of scales to measure selected scientific attitudes. Research in Science Education, , 13, 133-140.

Joyce, B. (1978). Selecting learning experiences: linking theory and and practise. Washington, Association for the Supervision of Curriculum

Joyce, B., & Weil, M. (1980). Social models of teaching (2nd. ed.) Englewood Cliffs: N.J. Prentice-Hall.

Kahle, J.B. (1982). Can positive minority attitudes lead to achievement gains in science? analysis of the 1977 National Assessment of Educational progress. Science Education, 66(4), 539-546.

Kahle, J.B. , & Yager, R. (1981). Current indicators for the Discipline of science education. Science Education, 65(1), 25-33.

Keys, W., & Ormerod, M.B. (1977). Some sex-related differences in the correlates of subject preference in the middle school years of secondary education. Educational Studies, 3, 111-116.

Klopfer, L.E. (1971). Evaluation of learning in science. In B.S. Bloom, J.T. Hastings & G.F. Madaus (Eds.). Handbook on Formative and Summative Evaluation of Student Learning. (pp. 559-641). New York: McGraw-Hill.

Klopfer, L.E. (1976). A structure for the affective domain in relation to science education. Science Education, 60(3), 299-312.

Klopfer, L.E. (1981). Editorial: assessment instruments in science education. Science Education, 65(3), 118-120.

Klopfer, L.E. (1983). Editorial: research and the crisis in science education. Science Education, 67(3), 283-284.

Koballa, T.R. (1983). Comments on "science teachers attitudes toward science and science teaching". Journal of Research in Science Teaching, 20(8), 803-804.

Koballa, T.R. (1984a) Designing a likert type scale to assess attitude toward energy conservation: a nine step process. Journal of Research in Science Teaching, 20(7), 709-723.

Koballa, T.R. (1984b). Changing attitudes toward energy conservation: the effect of development advancement on the salience of one-sided and two-sided persuasive communications. Journal of Research in Science Teaching, 21(7), 659-667.

Koballa, T.R., & Crawley, F.E. (1985). The influence of attitude on science teaching and learning. School Science and Mathematics, 85(3), 222-232.

Kozlow, M.J., & Nay, M.A. (1976). An approach to measuring scientific attitudes. Science Education, 60(2), 147-172.

Krathwohl, D.R., Bloom, B.S., & Masia, B.P.(1964). Taxonomy of educational objectives, handbook 2: the affective domain. New York: David McKay.

Krynowsky, B.A. (1985) Development of the Attitude Toward the Subject Science Scale. Eric Clearing House.

Kuhn, P.J. (1979). Study of attitudes of secondary school students toward energy related issues. Science Education, 63(5), 609-620.

Lawrenz, F.P. (1975). The relationship between science teacher characteristics and student achievement and attitude. Journal of Research in Science Teaching, 12(4), 433-437.

Lawrenz. F.P. (1976a). The prediction of student attitude toward science from student perception of the classroom learning environment. Journal of Research in Science Teaching, 13(6), 509-515.

Lawrenz. F.P. (1976b). Student perception of the classroom learning environment in biology, chemistry, and physics courses. Journal of Research in Science Teaching, 13(4), 315-323.

Lawrenz, F.P. (1977). The stability of student perceptions of the classroom learning environment. Journal of Research in Science Teaching, 14(1), 77-81.

Lawrenz, F.P., & Welch, W. (1983). Student perceptions of science classes taught by males and females. Journal of Research in Science Teaching. 20(7), 655-662.

Leece, J.R., & Mathews, J.C. (1976). Nuffield advanced chemistry research project. Casting the net with questionnaires and other sources of information. School Science Review. 57, 342-348.

Lewin, K. (1951). Field Theory in Social Science. New York: Harper.

Lijnse, P.J. (1983). Does science education improve the image of science? Science Education, 67(5), 575-582.

Long, J.C., Okey, J., & Yeany, R.H. (1981). The effects of a diagnostic prescriptive teaching strategy on student achievement and attitude in biology. Journal of Research in Science Teaching, 18(6), 515-523.

Lowery, L.F. (1966). Development of an attitude measuring instrument for science education. School Science and Mathematics, 66, 494-502.

Lowery, L.F. (1980). Toward improving the science education research enterprise. Journal of Research in Science Teaching, 17(4), 275-281.

Lowery, L.F., Bowyer, J., & Padilla, M.J. (1980). The science curriculum improvement study and student attitudes. Journal of Research in Science Teaching, 17(4), 327-355.

Lutz, F.W., & Ramsey, M.A. (1974). The use of anthropological field methods in education. Educational Research, 6(1), 5-9.

McGuire, W.J. (1985). The nature of attitudes and attitude change. In G. Lindzey & E. Aronson (Eds.) The handbook of social psychology (3rd ed.) New York: Random House.

MacMillan, J.H., & May, M.J. (1979). A study of factors influencing attitudes toward science of junior high school students. Journal of Research in Science Teaching, 16(4), 217-222.

Mager, R.F. (1968). Developing attitudes toward learning. Palo Alto, CA: Fearon Publishers.

Mallinson, G.G. (1977). A summary of research in science education - 1975. Science Education Supplement.

Mallow, J.V. (1981). New cures for science anxiety. Curriculum Review, 20(4), 389-391.

Malone, M.R., & Fleming M.L. (1983). The relationship of student characteristics and student performance as viewed by meta analysis research. Journal of Research in Science Teaching, 20(5), 481-495.

Manley, B. (1977). The relationship of learning environment to student attitudes towards chemistry. Dissertation Abstracts International, 1320A.

Mayer, V.J., & Richmond, J.M. (1982). An overview of assessment instruments in science. Science Education, 66(1), 49-66.

Messick, S. (1975). The standard problem: the meaning and values in measurement and evaluation. American Psychology, 30, 955-966.

Meyer, G.R. (1969). A test of interests. Milton, Queensland: Jacenda Press.

Moore, R.W., & Sutman, F.X. (1970). The development, field test, and validation of an inventory of scientific attitudes. Journal of Research in Science Teaching, 7(1), 85-94.

Moos, R.H. (1979). Evaluating educational environments: Procedures, measures, and findings. San Francisco: Jossey-Bass.,

Moos, R.H. (1980). Evaluating classroom learning environments. Studies in Educational Evaluation, 6(3), 239-252.

Moos, R.H., & Moos, B.S. (1978). Classroom social climate and student absences and grades. Journal of Educational Psychology, 70(2), 263-269.

Moos, R.H., & Trickett, E.J. (1974). Classroom environment scale manual. Palo Alto: Consulting Psychologists Press.

Moyer, R.H. (1975). An investigation of factors influencing environmental attitudes. School Science and Mathematics, 75(3), 266-269.

Munby, H. (1980). An evaluation of instruments which measure attitudes to science. In C. McFadden (Ed.), World Trends in Science Education. Halifax, Nova Scotia: Atlantic Institute of Education.

Munby, H. (1983). Thirty studies involving the "scientific attitude inventory": what confidence can we have in this instrument? Journal of Research in Science Teaching, 20(2), 141-162.

Munby, H., Kitto, J.K., & Wilson, R.J. (1976). Validating constructs in science education research: the construct "view of science". Science Education 60(3), 313-322.

Nagy, P. (1978). Subtest formation by cluster analysis of the Scientific Attitude Inventory. Journal of Research in Science Teaching, 15(3), 355-360.

Napier, J.D., & Riley, J.P. (1985). Relationship between affective determinants of achievement in science for seventeen-year olds. Journal of Research in Science Teaching, 22(4), 365-383.

Nay, M.A., & Crocker, R.K. (1970). Science teaching and the affective attributes of scientists. Science Education, 54(1), 59-67.

Newton, D.P. (1975). Attitudes to science. School Science Review, 57, 368-371.

Novick, S., & Duvdvani, D. (1976). The relationship between school and student variable the attitudes towards science of tenth grade students in Israel. Journal of Research in Science Teaching, 13(3), 259-265.

Nyberg, V.R., & Clarke, S.T. (1982). School subjects attitude scales. Alberta Journal of Educational Research, 28(2), 175-187.

Ormerod, M.B. (1973). Social and subject factors in attitudes to science. School Science Review, 54, 645-660.

Ormerod, M.B. (1979). Pupils attitudes to the social implications of science. European Journal of Science Education, 1(2), 177-190.

Ormerod, M.B., & Duckworth, D. (1975). Pupils attitudes to science: a review of research. Windsor, England: NFER Publishing Company.

Orpwood, G.W. (1976). Pupils attitudes to science: a review of research. Curriculum Theory Network, 6(1), 91-92.

Osborne, R. (1976). Using student attitudes to modify instruction in physics. Journal of Research in Science Teaching, 13(6), 525-532.

Osgood, C.F., Suci, G.J., and Tannebaum, P.H. (1957). The Measurement of Learning. Urbana: University of Illinois.

Ost, D.H., & White, R.S. (1979). Attitudes about scientists: an inventory for use in teaching or research. School Science and Mathematics, 79, 133-139.

Payne, D.A. (1977). The assessment of affect: nomothetic and idiographic. In W. Gephart and F. Marshall (Eds.) Evaluation in the Affective Domain. Phi Delta Kappa.

Pearl, R.E. (1973). The present status of science attitude measurement: history, theory, and availability of measurement instruments. School Science and Mathematics, 73(3), 375-381.

Peterson, R.W., & Carlson, G.R. (1979). A summary of research in science education - 1977. Science Education, 63(4), 425-553.

Power, C. (1977). A critical review of science classroom interaction studies. Studies in Science Education, 4, 1-30.

Power, C. (1981). Changes in students' attitudes towards science in transition between australian elementary and secondary schools. Journal of Research in Science Teaching, 18(1), 33-39.

Quinn, R.E. (1976). Using value sheets to modify attitudes toward environmental problems. Journal of Research in Science Teaching, 13(1), 65-69.

Rajecki, D.W. (1982). Attitudes: themes and advances. Sunderland Mass: Sinauer Associates.

Ramsay, G.A., & Howe, R.W. (1969). An analysis of research on instructional procedures in secondary school science. Science Teacher, 36(4), 72-81.

Ramsey, G. (1974). Science education: some choices for the teacher. Australian Science Teachers Journal, 20(3), 90-95.

Randhawa, B.A., & Fu, L.L. (1973). Assessment and effect of some classroom environment variables. Review of Educational Research, 43(3), 303-321.

Randhawa, B.S., & Michayluk, J.O. (1975). Learning environment in rural and urban classrooms. American Educational Research Journal, 12(3), 265-285.

Rentoul, A.J., & Fraser, B.J. (1980). Predicting learning from classroom individualization and actual-preferred congruence. Studies in Educational Evaluation, 6(3), 265-277.

Russell, J., & Hollander, S. (1975). A biology attitude scale. The American Biology Teacher, 37, 270-273.

Russell, T.L. (1981). What history of science, how much and why? Science Education, 65(1), 51-64.

Savada, D. (1976). Attitudes toward science of nonscience major under graduates: comparisons with the general public and effect of a science course. Journal of Research in Science Teaching, 13(1), 79-84.

Santiesteban, J.A.(1976). Attitudes of high school students toward science instructional procedures. Journal of Research in Science Teaching, 13(2), 171-175.

Schibeci, R.A. (1980). Science teachers and science-related attitudes. European Journal of Science Education, 3(4), 451-459.

Schibeci, R.A. (1981). Do teachers rate science attitude objectives as highly as cognitive objectives? Journal of Research in Science Teaching, 18(1), 69-72.

Schibeci, R.A. (1983) Selecting appropriate attitudinal objectives for school science. Science Education, 67(5), 595-603.

Schibeci, R.A. (1984). Attitudes to science: an update. Studies in Science Education, 11, 26-59.

Schibeci, R.A. (1986). The student opinion survey in chemistry: some cross-national data. Journal of Research in Science Teaching, 23(1), 21-27.

Schock, N.H. (1973). An analysis of the relationship which exists between cognitive and affective educational objectives. Journal of Research in Science Teaching, 20(3), 299-315.

Science Council of Canada. (1984). Science for Every Student Educating Canadians for Tomorrow's World. Hull, Quebec: Canadian Government Publishing.

Sherwood, R.D., & Herron, J.D. (1976). Effect on student attitude: individualized IAC versus conventional high school chemistry. Science Education, 60(4), 471-474.

Shrigley, R.L. (1978). The persuasive communication model: a theoretical approach for attitude change in science education. Journal of Research in Science Teaching, 15(5), 335-341.

Shrigley, R.L. (1983). The attitude concept and science teaching. Science Education, 67(4), 425-442.

Silbergeld, S., Koenig, G.A., & Manderscheid, R.W. (1975). Classroom psychosocial environment. Journal of Educational Research, , 69(2), 151-155.

Silbergeld, S., Koenig, G.A., & Manderscheid, R.W. (1976). Assessment of the psychosocial environment of the classroom: the class atmosphere scale. Journal of Social Psychology, 70(1), 65-76.

Simpson, R.D. (1977). Relating student feelings to achievement in science. What research says to the science teacher, Vol. 1. Washington, DC: National Science Teacher's Association.

Simpson, R.D., Shrum, J.W., & Renz, R.R. (1972). The science support scale: its appropriateness with high school students. Journal of Research in Science Teaching, 9(2), 123-126.

Simpson, R.D., Renz, R.R., & Shrum, J.W. (1976). Influence of instrument characteristics on student responses in attitude assessment. Journal of Research in Science Teaching, 13(3), 275-281.

Simpson, R.D., & Wasik, J.L. (1978). Correlation of selected affective behaviours and cognitive performance in a biology course for elementary teachers. Journal of Research in Science Teaching, 15(1), 65-71.

Sjoberg, L. (1983). Interest, achievement, and vocational choice. European Journal of Science Education, 5, 299-307.

Skirotnik, K.A. Instrument development and psychometric analysis of major scales utilized in a study of schools. Technical Report 4. Eric Clearing House.

Stake, R.E., & Easley, J.A., (1978). Case studies in Science Education. University of Illinois: Urbana-Champaign.

Steele, J.M., House, E.R., & Kerins, T. (1971). An instrument for assessing instructional climate through low-inference student judgements. American Educational Research Journal, 8, 447-466.

Steiner, R.L. (1973). Attitudes of Oregon high school seniors toward some environmentally oriented science related social issues. Science Education, 57(4), 417-435.

Steiner, R.L. (1980). Induced cognitive dissonance as a means of effecting change in school related attitudes. Journal of Research in Science Teaching, 17(1), 39-45.

Steinkamp, M.W., & Maehr, M.L. (1983). Affect, ability and science achievement: a quantitative synthesis of correlational research. Review of Educational Research, 53(3), 369-396.

Suedfeld, P. (1971). Attitude change. Chicago: Aldine Atherton Inc.

Tagiuri, R. (1968). The concept of organizational climate. In R. Tagiuri and G. H. Litwin (Eds.), Organizational Climate: Exploration of a Concept. Boston: Harvard University.

Talton, L.E. , & Simpson, R.D. (1985). Relationships between peer and individual attitudes toward science among adolescent students. Science Education, 69(1), 19-24.

Tamir, P., Arzi, A., & Zloto, D. (1974). Attitudes of Israeli high school students towards physics. Science Education, 58(1), 75-86.

Thorndike, R.L., & Hagen,E. (1969). Measurement and evaluation in psychology and education(3rd ed.). New York: John Wiley & Sons.

Thurstone, L.L. (1931). The measurement of attitudes. Journal of Abnormal and Social Psychology, 26, 249-269.

Tisher,C., & Power,C. (1976). Variations between ASEP and conventional learning environments. Australian Science Teachers Journal, 22(3), 35-39.

Tjosvold, D., & Santamaria, P. (1978). Effects of cooperation and teacher support on student attitudes toward decision making in the elementary science classroom. Journal of Research in Science Teaching, 15(5), 381-385.

Trickett, E.J., & Moos, R.H. (1973). Social environment of junior high and high school classrooms. Journal of Educational Psychology, 65(1), 93-102.

Towse, P.J. (1983). Do new science courses improve attitudes toward science? a study in Lesotho. Science Education, 67(2), 155-159.

Vitrogan, D. (1967). A method for determining a generalized attitude of high school students toward science. Science Education, 51(2), 170-175.

Vitrogan, D. (1969). Characteristics of a generalized attitude toward science. School Science and Mathematics, 69, 150-158.

Voss, B.E. (1983). A summary of research in science education - 1981. Science Education, 67(3), 289-419.

Walberg, H.J. (1968). Structural and affective aspects of classroom climate. Psychology of Schools, 5, 247-253.

Walberg, H.J. (1969). The social environment as a mediator of classroom learning. Journal of Educational Psychology, 60(6), 443-448.

Walberg, H.J. (1972). Social environment and individual learning: A test of the Bloom model. Journal of Educational Psychology, 63(1), 69-73.

Walberg, H.J. (Ed.). (1974). Educational environments and effects: evaluation, policy, and productivity. Berkeley: McCutchan.

Walberg, H.J. (1976). The psychology of learning environments: behavioral, structural, or perceptual? Review of Research in Education, , 4(2), 142-178.

Walberg, H.J. (1979). Educational environments and effects: Evaluation, research, and policy. Berkely: McCutchan.

Walberg, H.J., & Haertel, G.D. (1980). Validity and use of educational environment assessments. Studies in Educational Evaluation, 6(3), 225-238.

Walberg, H.J. (1984). Improving the productivity of americas' schools. Educational Leadership, 41(8), 19-27.

Ward, W.H. (1976). A test of the association of class size to students' attitudes toward science. Journal of Research in Science Teaching, 13(2), 137-143.

Wareing, C. (1982). Developing the WASP: Waering Attitudes toward Science Protocol. Journal of Research in Science Teaching, 19(8), 639-645.

Welch, W.W. (1973). Review of the research and evaluation program of Harvard Project Physics. Journal of Research in Science Teaching, 10(4), 365-378.

Welch, W.W. (1979). Curricular and longtitudinal effects on learning environments. In H.J. Walberg (Ed) Educational environments and effects. Berkley: McCutchan.

Welch, W., & Pella, M. (1969). The development of an instrument for inventorying knowledge of the processes of science. Journal of Research in Science Teaching, 6(1), 64-69.

Whitfield, R.C. (1979). Educational research and science teaching. School Science Review, 60, 411-430.

Wilkinson, W.J. (1974). Science teachers' opinions of the pupil and measurement of pupil role. Educational Review, 25(1), 46-53.

Willson, V.J. (1983). A meta-analysis of the relationships between science achievement and science attitude: kindergarten through college. Journal of Research in Science Teaching, 20(9), 839-850.

Willson, V.L., & Lawrenz, F. (1980). Relationship between teacher participation in WSF institutes and student attitudes and perception of the classroom learning environment. Journal of Research in Science Teaching, 17(4), 289-294.

Wilson, J.T. (1981). Toward a disciplined study of testing in science education. Science Education, 65(3), 259-270.

Yaakobi, D., & Peterson, K. (1981). Self-concept and perceptions of behavior: comparisons between U.S. and Israeli science students. Science Education, 65(3), 329-334.

Yager, R.F. (1978). Priorities for research in science education: a study committee report. Journal of Research in Science Teaching, 15(1), 99-107.

Yager, R.E., & Penick, J.E. (1984). What students have to say about science teaching and science teachers. Science Education, 68(2), 143-152.

Zeidler, D.L. (1984). Thirty studies involving the "scientific attitude inventory": what confidence can we have in this instrument? Journal of Research in Science Teaching, 21(3), 341-342.

List of Appendices

APPENDIX A.

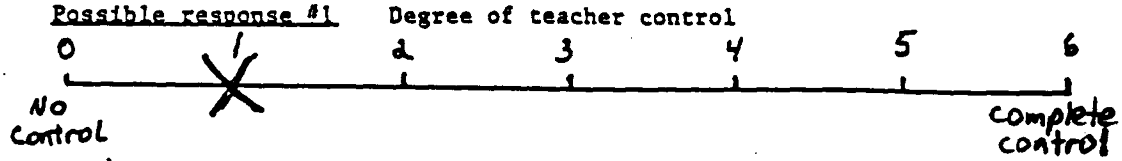
LEARNING ENVIRONMENT INVENTORY ANALYSIS

I would appreciate your assistance in finding out more about factors which probably influence teaching and learning in grade ten science classrooms. I will present, for your consideration, 15 probable factors. Please indicate the degree of control which you as a grade ten science teacher believe you have over each of the described factors. The degree of teacher control is indicated by placing an (X) on the number of your choice on the provided rating scale for each factor.

Example Factor APATHY

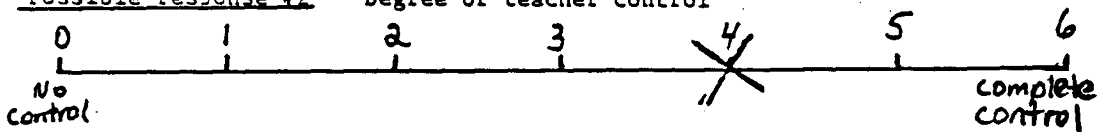
Meaning: The extent to which students feel left out of class activities.

Possible response #1 Degree of teacher control



An (X) placed on the number (1), would indicate that the teacher believes he or she can do very little to control or change student apathy in the classroom.

Possible response #2 Degree of teacher control



An (X) placed on the number (4), would indicate that the teacher believes he or she has considerable control to change the student apathy level in the classroom.

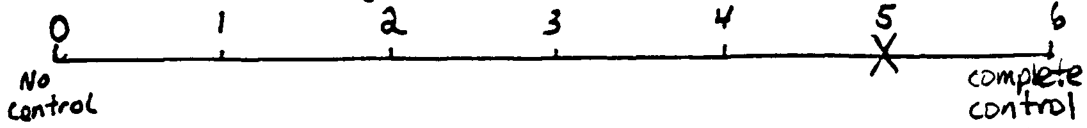
PROCEED TO THE NEXT PAGES AND PLEASE INDICATE THE DEGREE OF CONTROL YOU AS A GRADE TEN SCIENCE TEACHER BELIEVE YOU HAVE OVER EACH OF THE DESCRIBED FACTORS.

FACTORS

1. Factor · COHESIVENESS

Meaning: The extent to which students know help, and are friendly with each other.

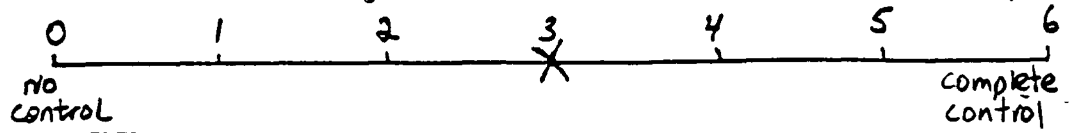
Degree of teacher control



2. Factor DIVERSITY

Meaning: The extent to which differences in students" interests exist and are provided for.

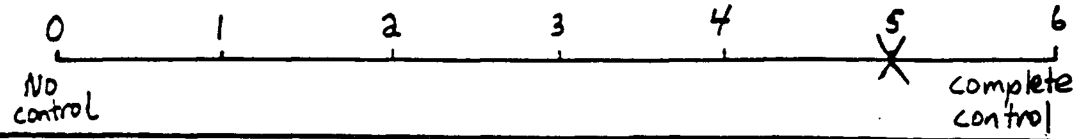
Degree of teacher control



3. Factor FORMALITY

Meaning: The extent to which behavior within the class is guided by formal rules.

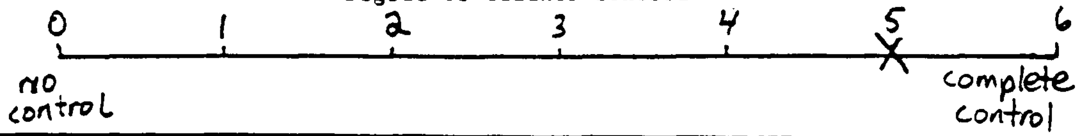
Degree of teacher control



4. Factor SPEED

Meaning: The extent to which class work is covered quickly.

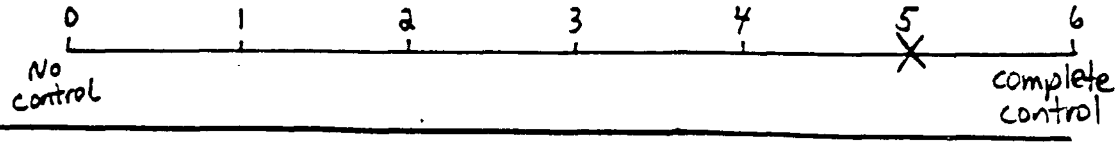
Degree of teacher control



5. Factor MATERIAL ENVIORNMENT

Meaning: The availability of adequate books, equipment, space, and lighting.

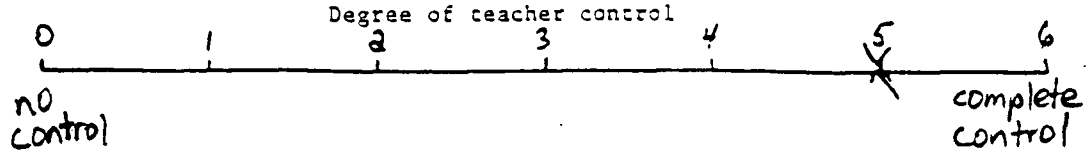
Degree of teacher control



6. Factor FRICTION

Meaning: The amount of tension and quarrelling among students.

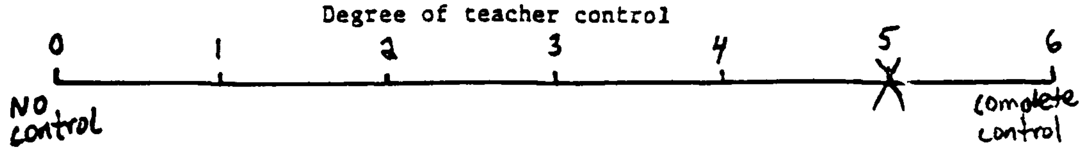
Degree of teacher control



7. Factor GOAL DIRECTION

Meaning: The degree of goal clarity in the class.

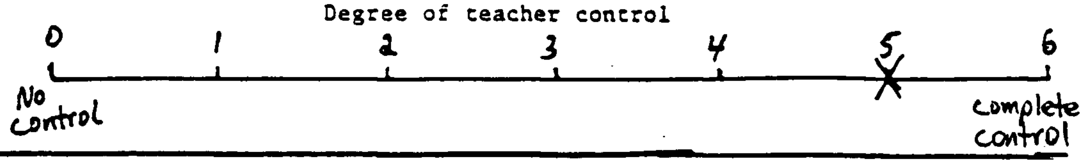
Degree of teacher control



8. Factor FAVORTISM

Meaning: The extent to which the teacher treats certain students more favorably than others.

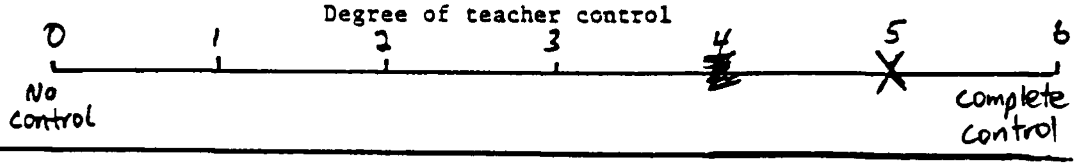
Degree of teacher control



9. Factor DIFFICULTY

Meaning: The extent to which students find difficulty with the work of the class.

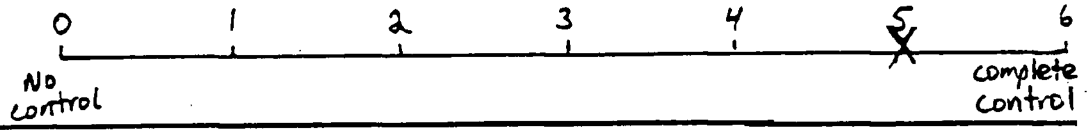
Degree of teacher control



10. Factor APATHY

Meaning: The extent to which students feel left out of class activities.

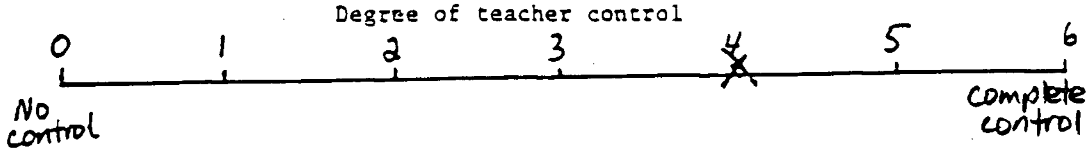
Degree of teacher control



11. Factor DEMOCRACY

Meaning: The extent to which students share equally in decision making related to the class.

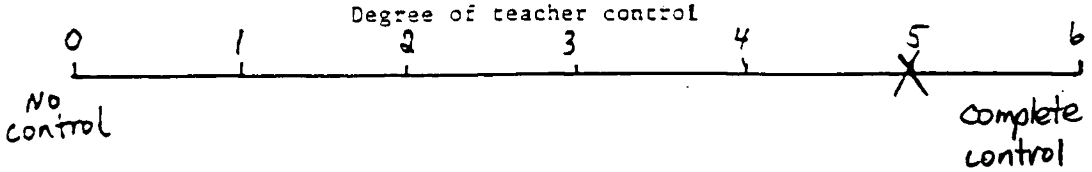
Degree of teacher control



12. Factor CLIQUENESS

Meaning: The extent to which students refuse to mix with the rest of the class.

Degree of teacher control



13. Factor SATISFACTION

Meaning: The extent of enjoyment of class work.

Degree of teacher control

0 1 2 3 4 5 [X] 6

No control — complete control

14. Factor DISORGANIZATION

Meaning: The extent to which classroom activities are confusing and poorly organized.

Degree of teacher control

0 1 2 3 4 5 [X] 6

No control — complete control

15. Factor COMPETITIVENESS

Meaning: The emphasis on students competing with each other

Degree of teacher control

0 1 2 3 [X] 4 5 6

No control — complete control

Can you think of any other classroom learning environment factors that may influence teaching and learning in the grade ten science classroom?

____

____

____

APPENDIX B: LEARNING ENVIRONMENT INVENTORY

(DIRECTIONS PAGE)

DIRECTIONS

The purpose of the questions in this booklet is to find out what your class is like. This is not a "test". You are asked to give your honest, frank opinions about the class which you are attending now.

Record your answer to each of the questions on the Response Sheet provided. Please make no marks on this booklet. Answer every question.

In answering each question, go through the following steps:

1. Read the statement carefully.

2. Think about how well the statement describes your class (the one you are now in).

3. Find the number on the Response Sheet that corresponds to the statement you are considering.

4. Indicate your answer by circling:

   SD if you **strongly disagree** with the statement,
   D if you **disagree** with the statement,
   A if you **agree** with the statement
   SA if you **strongly agree** with the statement.

5. If you change your mind about an answer, cross out the old answer and circle the new choice.

Be sure that the number on the Response Sheet corresponds to the number of the statement being answered in the booklet. Don't forget to record your name and other details on your Response Sheet.

Table IX

Reliabilities of LEI Variable Scales

Scale	Alpha Coefficient for Individuals		Intraclass Correlation for Groups		Test-Retest Reliability for Individuals
	(N=464)	(N=1048)	(N=29)	(N=64)	(N=139)
Cohesiveness	0.78	0.69	0.82	0.85	0.52
Diversity	0.58	0.54	0.43	0.31	0.43
Formality	0.64	0.76	0.82	0.92	0.55
Speed	0.77	0.70	0.71	0.81	0.51
Material Environment	0.65	0.56	0.76	0.81	0.64
Friction	0.78	0.72	0.77	0.83	0.73
Goal Direction	0.86	0.85	0.71	0.75	0.65
Favoritism	0.77	0.78	0.53	0.76	0.64
Difficulty	0.66	0.64	0.84	0.78	0.46
Apathy	0.83	0.82	0.79	0.74	0.61
Democracy	0.67	0.67	0.54	0.67	0.69
Cliqueness	0.74	0.65	0.77	0.71	0.68
Satisfaction	0.80	0.79	0.74	0.84	0.71
Disorganization	0.81	0.82	0.82	0.92	0.72
Competitiveness	0.78	0.78	-	0.56	-

All reliability estimates are based on samples of senior high school students in North America. Alpha coefficients have been estimated for a sample of 464 students in 1967 and a sample of 1,048 students in 1969. Intraclass correlations were calculated on a sample of 29 classes in 1967 and of 64 classes in 1969. Test-retest data were collected in 1970 from a sample of 139 individuals.

Table X

LEI Variable Scale Intercorrelations

Scale	Scale Intercorrelations															Mean Correl. with other Scales
	Coh	Div	For	Sp	ME	Fri	GD	Fav	Dif	Ap	Dem	Cli	Sat	Dis	Comp	
Cohesiveness	-															14
Diversity	04	-														16
Formality	-09	-04	-													18
Speed	08	-01	20	-												17
Material Environment	14	06	22	00	-											24
Friction	-16	31	-06	05	-22	-										36
Goal Direction	14	-26	42	-17	34	-38	-									37
Favoritism	-09	16	-03	23	-40	53	-40	-								32
Difficulty	27	-17	21	57	13	-21	08	00	-							16
Apathy	-32	16	-17	16	-38	61	-63	45	-21	-						39
Democracy	12	-28	09	-20	32	-58	43	-63	-01	-55	-					34
Cliqueness	-27	21	-21	-02	-25	69	-36	34	-20	53	-40	-				33
Satisfaction	10	-20	15	-40	37	-57	70	-52	-04	-73	54	-45	-			39
Disorganization	-07	23	-50	12	-48	47	-77	54	-14	60	-50	48	-71	-		40
Competitiveness	-13	04	11	-10	00	13	06	18	06	00	-08	17	-03	04	-	08

Correlations are based on means of 149 physics classes (1967 data) for all scales except Competitiveness, for which 62 classes (1969 data) were used. Decimals have been omitted, so correlations should be read in hundredths.

Table XI.

Additional LEI Reliability Data

Variable Scale	Test-Retest	Internal Consistency
Formality	.73	.62
Speed	.83	.76
Goal Direction	.81	.77
Favoritism	.74	.70
Difficulty	.77	.76
Apathy	.79	.72
Democracy	.60	.79
Satisfaction	.88	.77
Disorganization	.73	.72
Competitiveness	.73	.73

Test-Retest reliability coefficients were based on a 3-4 week time interval with 26 students. Internal consistency coefficients are Hoyt estimates based on the posthoc analysis of responses of 231 students in the sample.

ATTITUDE TOWARD THE SUBJECT SCIENCE SCALE

Please do not turn the page until you are asked to do so.

SCHOOL ______________________ SCALE NUMBER ___________

PURPOSE

The purpose of this scale is to find out your overall thoughts or feelings toward the topics and activities within the science course you are taking this school year. You will be asked to respond to some statements about activities related to this science course. Please respond to all of the statements honestly and to the best of your ability. This is not a test. Your answers are confidential.

INSTRUCTIONS AND EXAMPLE

Instructions

1. Read the statement carefully.
2. Note the words at the opposite ends of the scales given to you. Pick the word from the end of each scale that best describes how you think or feel about the activity in the statement.
3. Put an X in one of the labelled spaces at the end of the scale that you picked. This X shows how strongly you think or feel about the activity in the statement.

Example

Here is an example of a statement and one scale which has been responded to:

MY READING A SCIENCE RELATED MAGAZINE ARTICLE IS

BORING	____ :	____ :	____ :	____ :	____ :	X :	____ INTERESTING
	extremely	quite	slightly	undecided	slightly	quite	extremely

In this example, the X placed in the quite space on the INTERESTING end of the scale shows that the person responding to this statement thinks or feels that the reading of a science related magazine article is quite interesting.

4. Work rapidly, and give your first thought or feeling about the activity in the statement. Please remain quiet until everyone is finished.

REMEMBER

*THERE ARE 3 SCALES PER STATEMENT. RESPOND TO ALL OF THE STATEMENTS AND SCALES.

*ANSWER HONESTLY AND TO THE BEST OF YOUR ABILITY.

*THIS IS NOT A TEST. YOUR ANSWERS ARE CONFIDENTIAL.

ARE THERE ANY QUESTIONS? ....YOU MAY BEGIN

ALL OF THE FOLLOWING STATEMENTS ARE RELATED TO YOUR SCIENCE COURSE THIS SCHOOL YEAR.

Please respond to all three scales for each statement.

1. MY READING THE SCIENCE TEXT AT LEAST ONCE A WEEK IS

	extremely	quite	slightly	undecided	slightly	quite	extremely	
INTERESTING	____ :	____ :	____ :	____ :	____ :	____ :	____	BORING
PLEASANT	____ :	____ :	____ :	____ :	____ :	____ :	____	UNPLEASANT
AWFUL	____ :	____ :	____ :	____ :	____ :	____ :	____	NICE

2. MY ACTIVELY PARTICIPATING IN MOST OF THE LAB ACTIVITIES IS

	extremely	quite	slightly	undecided	slightly	quite	extremely	
INTERESTING	____ :	____ :	____ :	____ :	____ :	____ :	____	BORING
PLEASANT	____ :	____ :	____ :	____ :	____ :	____ :	____	UNPLEASANT
NICE	____ :	____ :	____ :	____ :	____ :	____ :	____	AWFUL

3. MY WATCHING A T.V. PROGRAM ABOUT SCIENCE AT LEAST ONCE A MONTH IS

	extremely	quite	slightly	undecided	slightly	quite	extremely	
INTERESTING	____ :	____ :	____ :	____ :	____ :	____ :	____	BORING
UNPLEASANT	____ :	____ :	____ :	____ :	____ :	____ :	____	PLEASANT
AWFUL	____ :	____ :	____ :	____ :	____ :	____ :	____	NICE

4. MY TRYING MY BEST TO KEEP A GOOD SCIENCE NOTEBOOK IS

	extremely	quite	slightly	undecided	slightly	quite	extremely	
INTERESTING	____ :	____ :	____ :	____ :	____ :	____ :	____	BORING
PLEASANT	____ :	____ :	____ :	____ :	____ :	____ :	____	UNPLEASANT
AWFUL	____ :	____ :	____ :	____ :	____ :	____ :	____	NICE

ALL OF THE FOLLOWING STATEMENTS ARE RELATED TO YOUR SCIENCE COURSE THIS SCHOOL YEAR.

5. MY READING A SCIENCE RELATED MAGAZINE ARTICLE AT LEAST ONCE A MONTH IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
NICE	extremely	quite	slightly	undecided	slightly	quite	extremely	AWFUL

6. MY ASKING THE SCIENCE TEACHER QUESTIONS ABOUT SCIENCE IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

7. MY TRYING TO FIND OUT MORE ABOUT SCIENCE THAN WHAT WE LEARN IN CLASS IS

BORING	extremely	quite	slightly	undecided	slightly	quite	extremely	INTERESTING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
NICE	extremely	quite	slightly	undecided	slightly	quite	extremely	AWFUL

8. MY TRYING MY BEST TO SOLVE SCIENCE PROBLEMS WE ARE GIVEN IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
PLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	UNPLEASANT
NICE	extremely	quite	slightly	undecided	slightly	quite	extremely	AWFUL

ALL OF THE FOLLOWING STATEMENTS ARE RELATED TO YOUR SCIENCE COURSE THIS SCHOOL YEAR

9. MY TAKING SCIENCE AS A SCHOOL SUBJECT IS

	extremely	quite	slightly	undecided	slightly	quite	extremely	
BORING	____ :	____ :	____ :	____ :	____ :	____ :	____	INTERESTING
UNPLEASANT	____ :	____ :	____ :	____ :	____ :	____ :	____	PLEASANT
AWFUL	____ :	____ :	____ :	____ :	____ :	____ :	____	NICE

10. MY TRYING MY BEST TO GET A GOOD SCIENCE MARK IS

	extremely	quite	slightly	undecided	slightly	quite	extremely	
INTERESTING	____ :	____ :	____ :	____ :	____ :	____ :	____	BORING
UNPLEASANT	____ :	____ :	____ :	____ :	____ :	____ :	____	PLEASANT
AWFUL	____ :	____ :	____ :	____ :	____ :	____ :	____	NICE

11. MY LISTENING CLOSELY TO THE TEACHER TALKING ABOUT SCIENCE IS

	extremely	quite	slightly	undecided	slightly	quite	extremely	
INTERESTING	____ :	____ :	____ :	____ :	____ :	____ :	____	BORING
UNPLEASANT	____ :	____ :	____ :	____ :	____ :	____ :	____	PLEASANT
AWFUL	____ :	____ :	____ :	____ :	____ :	____ :	____	NICE

12. MY TRYING TO DO SCIENCE ASSIGNMENTS TO THE BEST OF MY ABILITY IS

	extremely	quite	slightly	undecided	slightly	quite	extremely	
BORING	____ :	____ :	____ :	____ :	____ :	____ :	____	INTERESTING
UNPLEASANT	____ :	____ :	____ :	____ :	____ :	____ :	____	PLEASANT
NICE	____ :	____ :	____ :	____ :	____ :	____ :	____	AWFUL

OF THE FOLLOWING STATEMENTS ARE RELATED TO YOUR SCIENCE COURSE THIS SCHOOL YEAR.

---

13. MY TRYING TO APPLY THE SCIENCE WE LEARN OUTSIDE OF CLASS IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
PLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	UNPLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

---

14. MY TAKING UP OF MOST OF THE SCIENCE TOPICS IS

BORING	extremely	quite	slightly	undecided	slightly	quite	extremely	INTERESTING
PLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	UNPLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

---

15. MY TRYING TO DO SCIENCE EXPERIMENTS OUTSIDE OF CLASS IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

---

16. From the following list of grade 10 subjects, could you please rate the classes from most to least liked. The most liked subject is written by you into space #1, the second most liked into space #2 . . . and the least liked goes into space #5.

Grade 10 Subjects	Your Rating
1. English	1. ________ most liked
2. Math	2. ________
3. Science	3. ________
4. Social Studies	4. ________
5. Physical Ed.	5. ________ least liked

THANK YOU FOR YOUR ASSISTANCE AND COOPERATION!

SCHOOL_______________________ INITIALS_______________

Grade 8/12

School Science

1. I LIKE TO STUDY SCIENCE IN SCHOOL.

Strongly Disagree	Disagree	Can't Decide	Agree	Strongly Agree

2. I FEEL THE STUDY OF SCIENCE IN SCHOOL IS IMPORTANT.

Strongly Disagree	Disagree	Can't Decide	Agree	Strongly Agree

3. SCIENCE IS DULL.

Strongly Disagree	Disagree	Can't Decide	Agree	Strongly Agree

4. I DO NOT ENJOY SCIENCE.

Strongly Disagree	Disagree	Can't Decide	Agree	Strongly Agree

5. I WOULD LIKE TO STUDY MORE SCIENCE.

Strongly Disagree	Disagree	Can't Decide	Agree	Strongly Agree

6. SCIENCE CLASSES ARE BORING.

Strongly Disagree	Disagree	Can't Decide	Agree	Strongly Agree

7. SCIENCE IS A VALUABLE SUBJECT.

Strongly Disagree	Disagree	Can't Decide	Agree	Strongly Agree

CLASSROOM FACTORS THAT INFLUENCE STUDENT ATTITUDES TOWARD THE SUBJECT SCIENCE

INRODUCTION OF SELF(name,affiliation)

PURPOSE OF THE INTERVIEW

The purpose of this interview,which you have consented to,is to find out about your thoughts and feelings about both your attitude toward the subject science and the activities that go on in your science class. This information will be useful to all science teachers by giving them a better idea about the student's viewpoint.

Please be honest and answer the questions to the best of your ability. Your answers will not be made known to anybody else. If you do not understand a question please ask me about it. Moreover, feel free to add any other comments related to any of the questions.(eg. Why do you think or feel this way about your answer to the question)

Section A (Put an X in the space that best describes how you think or feel about the question)

1. MY TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

GOOD ....:..........:..........:..........:..........:..........:.......... BAD
extremely quite slightly undecided slightly quite extremely

Why?

2. MY TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

USEFUL ....:..........:..........:..........:..........:..........:.......... USELESS
extremely quite slightly undecided slightly quite extremely

Why?

3. MY TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

HARD ....:..........:..........:..........:..........:..........:.......... EASY
extremely quite slightly undecided slightly quite extremely

Why?

4. MOST OF MY FRIENDS THINK THAT TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

GOOD ....:..........:..........:..........:..........:..........:..........BAD
extremely quite slightly undecided slightly quite extremely

Why?

5. MOST OF MY FRIENDS THINK THAT TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

USEFUL ....:..........:..........:..........:..........:..........:.......... USELESS
extremely quite slightly undecided quite slightly : extremely

Why?

6. MOST OF MY FRIENDS THINK THAT TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

HARD :..........:..........:..........:..........:..........:..........:.......... EASY

extremely	quite	slightly	undecided	quite	slightly	extremely

why?

Please complete the following statement with a word or short phrase:

IN MY OPINION, MY TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

____

____

Section B (Please give your honest thoughts or feelings on the following questions:)

1. Could you please list five things that go on in your grade ten science class that makes you like or dislike grade ten science as a school subject:

a.

b.

c.

d.

e.

2. If you were a grade ten teacher, what two things would you do in your class to try to make your students have positive attitudes toward the subject science?

THANK YOU VERY MUCH FOR YOUR TIME AND COOPERATION!

Mr. Bernie Krynowsky
University of British Columbia

APPENDIX F. TEACHER INTERVIEW SCHEDULE

WHAT CAN GRADE TEN SCIENCE TEACHERS DO IN THEIR CLASSROOMS IN ORDER TO PROMOTE MORE POSITIVE STUDENT ATTITUDES TOWARD THE SUBJECT SCIENCE?

Relate content to normal life. (sports) - more interesting. Requires out of curriculum knowledge by teacher.

More variety in teaching Labs, videos, filmstrips, fieldtrips (Problems with feasibility time however)

Try to make students understand the importance of science (incentive - motivation aroused)

Need smaller class size - environment more positive. Participation - sharing is improved.

APPENDIX G. KENDALL COEFFICENT ANALYSIS

20 JUN 85 KENDALL CONCORDANCE FOR LEIA
10:37:01 University of British Columbia

NUMBER OF VALID OBSERVATIONS (LISTWISE) = 20.00

VARIABLE F1

MEAN	2.800	S.E. MEAN	.236	STD DEV	1.056
VARIANCE	1.116	KURTOSIS	-1.312	S.E. KURT	1.938
SKEWNESS	-.155	S.E. SKEW	.512	RANGE	3.000
MINIMUM	1.000	MAXIMUM	4.000	SUM	56.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

VARIABLE F2

MEAN	3.000	S.E. MEAN	.205	STD DEV	.918
VARIANCE	.842	KURTOSIS	-.687	S.E. KURT	1.938
SKEWNESS	.454	S.E. SKEW	.512	RANGE	3.000
MINIMUM	2.000	MAXIMUM	5.000	SUM	60.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

VARIABLE F3

MEAN	4.950	S.E. MEAN	.114	STD DEV	.510
VARIANCE	.261	KURTOSIS	1.649	S.E. KURT	1.938
SKEWNESS	-.112	S.E. SKEW	.512	RANGE	2.000
MINIMUM	4.000	MAXIMUM	6.000	SUM	99.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

VARIABLE F4

MEAN	4.500	S.E. MEAN	.224	STD DEV	1.000
VARIANCE	1.000	KURTOSIS	.813	S.E. KURT	1.938
SKEWNESS	-.877	S.E. SKEW	.512	RANGE	4.000
MINIMUM	2.000	MAXIMUM	6.000	SUM	90.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

NUMBER OF VALID OBSERVATIONS (LISTWISE) = 20.00

VARIABLE F5

MEAN	2.300	S.E. MEAN	.356	STD DEV	1.593
VARIANCE	2.537	KURTOSIS	-.013	S.E. KURT	1.938
SKEWNESS	.841	S.E. SKEW	.512	RANGE	6.000
MINIMUM	.000	MAXIMUM	6.000	SUM	46.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

VARIABLE F6

MEAN	3.050	S.E. MEAN	.352	STD DEV	1.572
VARIANCE	2.471	KURTOSIS	-1.046	S.E. KURT	1.938
SKEWNESS	.270	S.E. SKEW	.512	RANGE	5.000
MINIMUM	1.000	MAXIMUM	6.000	SUM	61.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

- -

VARIABLE F7

MEAN	5.300	S.E. MEAN	.128	STD DEV	.571
VARIANCE	.326	KURTOSIS	-.395	S.E. KURT	1.938
SKEWNESS	-.038	S.E. SKEW	.512	RANGE	2.000
MINIMUM	4.000	MAXIMUM	6.000	SUM	106.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

- -

VARIABLE F8

MEAN	4.950	S.E. MEAN	.223	STD DEV	.999
VARIANCE	.997	KURTOSIS	2.727	S.E. KURT	1.938
SKEWNESS	-1.301	S.E. SKEW	.512	RANGE	4.000
MINIMUM	2.000	MAXIMUM	6.000	SUM	99.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

- -

NUMBER OF VALID OBSERVATIONS (LISTWISE) = 20.00

VARIABLE F9

MEAN	3.500	S.E. MEAN	.256	STD DEV	1.147
VARIANCE	1.316	KURTOSIS	3.606	S.E. KURT	1.938
SKEWNESS	-1.395	S.E. SKEW	.512	RANGE	5.000
MINIMUM	.000	MAXIMUM	5.000	SUM	70.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

- -

VARIABLE F10

MEAN	3.600	S.E. MEAN	.303	STD DEV	1.353
VARIANCE	1.832	KURTOSIS	-1.469	S.E. KURT	1.938
SKEWNESS	.119	S.E. SKEW	.512	RANGE	4.000
MINIMUM	2.000	MAXIMUM	6.000	SUM	72.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

- -

VARIABLE F11

MEAN	4.750	S.E. MEAN	.216	STD DEV	.967
VARIANCE	.934	KURTOSIS	-.817	S.E. KURT	1.938
SKEWNESS	-.219	S.E. SKEW	.512	RANGE	3.000
MINIMUM	3.000	MAXIMUM	6.000	SUM	95.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

- -

VARIABLE F12

MEAN	2.350	S.E. MEAN	.244	STD DEV	1.089
VARIANCE	1.187	KURTOSIS	-1.125	S.E. KURT	1.938
SKEWNESS	.292	S.E. SKEW	.512	RANGE	3.000
MINIMUM	1.000	MAXIMUM	4.000	SUM	47.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

NUMBER OF VALID OBSERVATIONS (LISTWISE) = 20.00

VARIABLE F13

MEAN	3.650	S.E. MEAN	.209	STD DEV	.933
VARIANCE	.871	KURTOSIS	-.734	S.E. KURT	1.938
SKEWNESS	-.055	S.E. SKEW	.512	RANGE	3.000
MINIMUM	2.000	MAXIMUM	5.000	SUM	73.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

VARIABLE F14

MEAN	5.500	S.E. MEAN	.136	STD DEV	.607
VARIANCE	.368	KURTOSIS	-.213	S.E. KURT	1.938
SKEWNESS	-.785	S.E. SKEW	.512	RANGE	2.000
MINIMUM	4.000	MAXIMUM	6.000	SUM	110.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

VARIABLE F15

MEAN	3.600	S.E. MEAN	.336	STD DEV	1.501
VARIANCE	2.253	KURTOSIS	-1.059	S.E. KURT	1.938
SKEWNESS	-.369	S.E. SKEW	.512	RANGE	5.000
MINIMUM	1.000	MAXIMUM	6.000	SUM	72.000

VALID OBSERVATIONS - 20 MISSING OBSERVATIONS - 0

I.

*** * * * M U L T I P L E   R E G R E S S I O N * * * ***

Equation Number 1 Dependent Variable.. FITEM

Descriptive Statistics are printed on Page 5

Beginning Block Number 1. Method: Forward

Variable(s) Entered on Step Number 1.. DATA8

Multiple R	.48476	Analysis of Variance			
R Square	.23499		DF	Sum of Squares	Mean Square
Adjusted R Square	.23165	Regression	1	82999.41172	82999.41172
Standard Error	34.35026	Residual	229	270206.33720	1179.94034

F = 70.34204 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
DATA8	5.449007	.649696	.484756	8.387	.0000
(Constant)	113.697330	10.670964		10.655	.0000

------------- Variables not in the Equation -------------

Variable	Beta In	Partial	Min Toler	T	Sig T
DATA1	.084545	.096616	.999077	1.466	.1441
DATA2	-.013345	-.013160	.744006	-.199	.8427
DATA3	.159921	.138760	.575952	2.116	.0355
DATA4	-.098377	-.104590	.864690	-1.588	.1137
DATA5	-.099037	-.096394	.724724	-1.462	.1450
DATA6	-.206449	-.219217	.862562	-3.393	.0008
DATA7	.009687	.010203	.848588	.154	.8777
DATA9	-.103166	-.084585	.514258	-1.282	.2012
DATA10	.091540	.104640	.999633	1.589	.1135

* *

Variable(s) Entered on Step Number 2.. DATA6

Multiple R	.52130	Analysis of Variance			
R Square	.27175		DF	Sum of Squares	Mean Square
Adjusted R Square	.26536	Regression	2	95984.44799	47992.22400
Standard Error	33.58815	Residual	228	257221.30093	1128.16360

F = 42.54013 Signif F = .0000

2.

*** * * * MULTIPLE REGRESSION * * * ***

Equation Number 1 Dependent Variable.. FITEM

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
DATA8	4.588688	.684023	.408220	6.708	.0000
DATA6	-2.627987	.774618	-.206449	-3.393	.0008
(Constant)	173.741483	20.545263		8.457	.0000

------------- Variables not in the Equation -------------

Variable	Beta In	Partial	Min Toler	T	Sig T
DATA1	.059386	.068901	.846382	1.041	.2992
DATA2	-.057898	-.057445	.619087	-.867	.3869
DATA3	.121172	.106252	.554405	1.610	.1088
DATA4	-.066728	-.071750	.786289	-1.084	.2796
DATA5	-.156242	-.152033	.595023	-2.318	.0214
DATA7	-.017361	-.018585	.769612	-.280	.7797
DATA9	-.043150	-.035260	.486281	-.532	.5955
DATA10	.111261	.129734	.854390	1.971	.0499

* *

Variable(s) Entered on Step Number 3.. DATA5

Multiple R	.53720
R Square	.28859
Adjusted R Square	.27918
Standard Error	33.27074

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	101929.90734	33976.63578
Residual	227	251275.84158	1106.94203

F = 30.69414 Signif F = .0000

------------------ Variables in the Equation ------------------

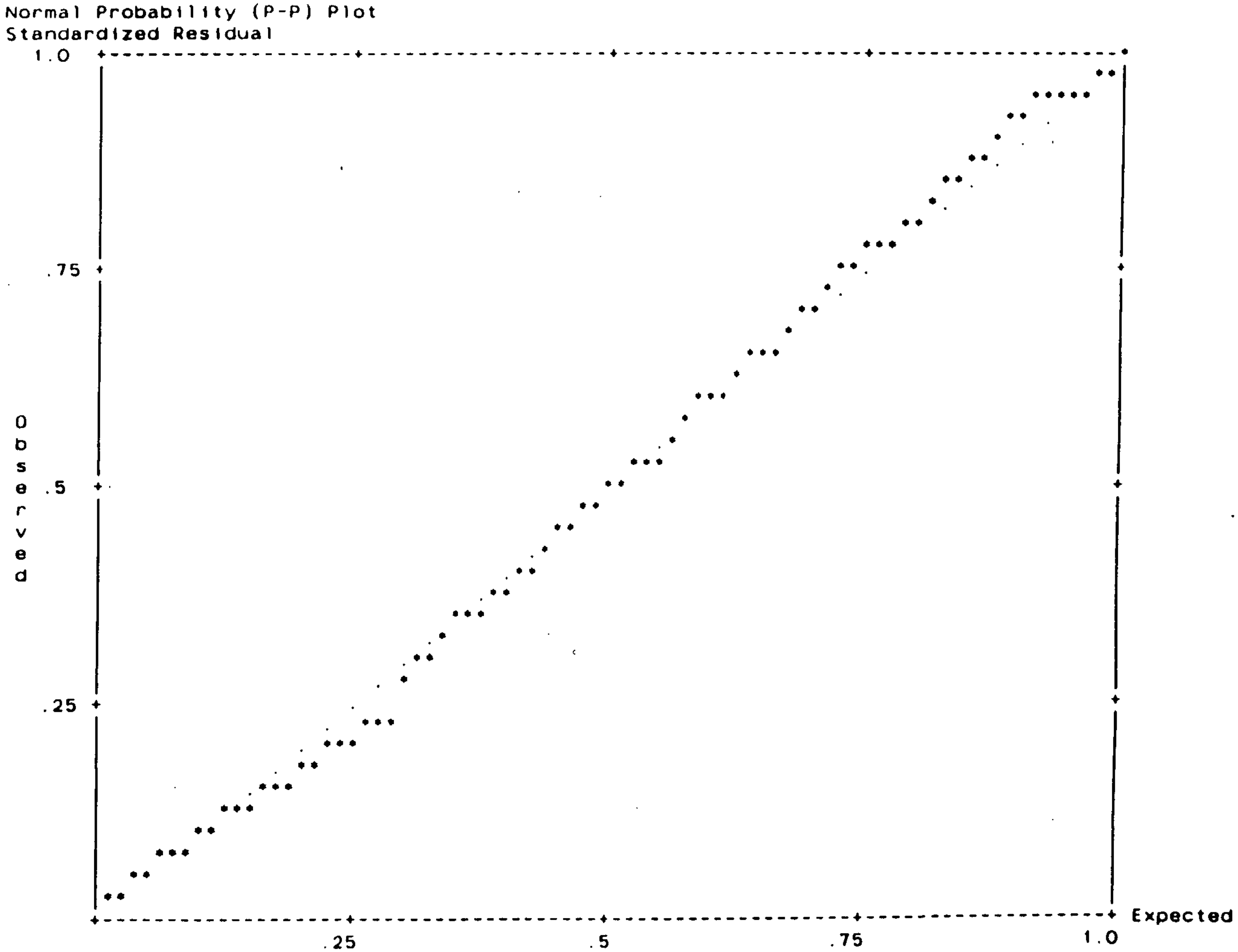
Variable	B	SE B	Beta	T	Sig T
DATA8	3.535747	.815784	.314548	4.334	.0000
DATA6	-3.029628	.786626	-.238001	-3.851	.0002
DATA5	-1.753821	.756755	-.156242	-2.318	.0214
(Constant)	232.155608	32.395407		7.166	.0000

------------- Variables not in the Equation -------------

Variable	Beta In	Partial	Min Toler	T	Sig T
DATA1	.108842	.121811	.588312	1.845	.0664
DATA2	.011924	.010745	.543811	.162	.8718
DATA3	.126491	.112169	.423570	1.697	.0911
DATA4	-.076690	-.083240	.546727	-1.256	.2105
DATA7	-.022513	-.024368	.554848	-.366	.7144
DATA9	-.037773	-.031216	.406431	-.470	.6392
DATA10	.094495	.110327	.594282	1.669	.0965

End Block Number 1 PIN = .050 Limits reached.

APPENDIX I. Plot of Standardized Residuals in Regression Equation



APPENDIX J. Backward Regression Equation Data

* * * * M U L T I P L E R E G R E S S I O N * * * *

Equation Number 1 Dependent Variable.. FITEM

Descriptive Statistics are printed on Page 5

Beginning Block Number 1. Method: Enter

Variable(s) Entered on Step Number
1.. DATA10
2.. DATA7
3.. DATA1
4.. DATA6
5.. DATA2
6.. DATA4
7.. DATA9
8.. DATA5
9.. DATA3
10.. DATA8

Multiple R	.56284
R Square	.31679
Adjusted R Square	.28574
Standard Error	33.11909

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	10	111893.46604	11189.34660
Residual	220	241312.28288	1096.87401

F = 10.20112 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
DATA10	1.291916	.750823	.102801	1.721	.0867
DATA7	-.641784	1.071175	-.037346	-.599	.5497
DATA1	1.195747	.942793	.080322	1.268	.2060
DATA6	-2.884336	.827643	-.226587	-3.485	.0006
DATA2	.059463	.767916	.006145	.077	.9383
DATA4	-.818684	.789273	-.072924	-1.037	.3008
DATA9	.291746	1.003353	.025592	.291	.7715
DATA5	-2.021809	.890080	-.180116	-2.271	.0241
DATA3	.946890	.924887	.085324	1.024	.3071
DATA8	2.920508	1.078093	.259815	2.709	.0073
(Constant)	199.078048	49.725405		4.004	.0001

End Block Number 1 All requested variables entered.

* * * * M U L T I P L E R E G R E S S I O N * * * *

Equation Number 1 Dependent Variable.. FITEM

Beginning Block Number 2. Method: Backward

Variable(s) Removed on Step Number 11.. DATA2

Multiple R	.56283	Analysis of Variance			
R Square	.31678		DF	Sum of Squares	Mean Square
Adjusted R Square	.28895	Regression	9	111886.88918	12431.87658
Standard Error	33.04452	Residual	221	241318.85973	1091.94054

F = 11.38512 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
DATA10	1.304071	.732577	.103768	1.780	.0764
DATA7	-.639523	1.068366	-.037215	-.599	.5501
DATA1	1.210114	.922274	.081287	1.312	.1908
DATA6	-2.894671	.814971	-.227399	-3.552	.0005
DATA4	-.810240	.779944	-.072172	-1.039	.3000
DATA9	.291164	1.001066	.025541	.291	.7714
DATA5	-1.991684	.798749	-.177432	-2.494	.0134
DATA3	.929851	.896306	.083788	1.037	.3007
DATA8	2.911500	1.069385	.259014	2.723	.0070
(Constant)	199.564389	49.216101		4.055	.0001

------------- Variables not in the Equation -------------

Variable	Beta In	Partial	Min Toler	T	Sig T
DATA2	.006145	.005221	.337601	.077	.9383

* *

Variable(s) Removed on Step Number 12.. DATA9

Multiple R	.56260	Analysis of Variance			
R Square	.31651		DF	Sum of Squares	Mean Square
Adjusted R Square	.29188	Regression	8	111794.51545	13974.31443
Standard Error	32.97632	Residual	222	241411.23347	1087.43799

F = 12.85068 Signif F = .0000

*** * * * MULTIPLE REGRESSION * * * ***

Equation Number 1 Dependent Variable.. FITEM

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
DATA10	1.317027	.729712	.104799	1.805	.0725
DATA7	-.609996	1.061337	-.035496	-.575	.5660
DATA1	1.202675	.920016	.080787	1.307	.1925
DATA6	-2.852258	.800164	-.224067	-3.565	.0004
DATA4	-.753656	.753732	-.067132	-1.000	.3184
DATA5	-1.973859	.794751	-.175844	-2.484	.0137
DATA3	.863970	.865424	.077852	.998	.3192
DATA8	2.791040	.983895	.248297	2.837	.0050
(Constant)	205.166144	45.197681		4.539	.0000

------------- Variables not in the Equation -------------

Variable	Beta In	Partial	Min Toler	T	Sig T
DATA2	.005972	.005073	.396645	.075	.9400
DATA9	.025541	.019561	.341578	.291	.7714

* *

Variable(s) Removed on Step Number 13.. DATA7

Multiple R	.56169
R Square	.31550
Adjusted R Square	.29401
Standard Error	32.92677

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	7	111435.30219	15919.32888
Residual	223	241770.44673	1084.17241

F = 14.68339 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
DATA10	1.302123	.728155	.103613	1.788	.0751
DATA1	1.230438	.917367	.082652	1.341	.1812
DATA6	-2.800542	.793894	-.220004	-3.528	.0005
DATA4	-.678460	.741174	-.060434	-.915	.3610
DATA5	-1.962255	.793301	-.174810	-2.474	.0141
DATA3	.865130	.864121	.077956	1.001	.3178
DATA8	2.686630	.965525	.239009	2.783	.0059
(Constant)	194.001744	40.749203		4.761	.0000

------------- Variables not in the Equation -------------

Variable	Beta In	Partial	Min Toler	T	Sig T
DATA2	.004757	.004039	.410924	.060	.9521
DATA7	-.035496	-.038546	.401853	-.575	.5660
DATA9	.020546	.015796	.356755	.235	.8141

**** M U L T I P L E   R E G R E S S I O N ****

Equation Number 1 Dependent Variable.. FITEM

Variable(s) Removed on Step Number 14.. DATA4

Multiple R	.55940	Analysis of Variance			
R Square	.31292		DF	Sum of Squares	Mean Square
Adjusted R Square	.29452	Regression	6	110526.84110	18421.14018
Standard Error	32.91486	Residual	224	242678.90782	1083.38798

F = 17.00327 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
DATA10	1.150238	.708742	.091527	1.623	.1060
DATA1	1.425017	.892077	.095722	1.597	.1116
DATA6	-2.863328	.790639	-.224937	-3.622	.0004
DATA5	-1.992380	.792331	-.177494	-2.515	.0126
DATA3	1.045834	.840966	.094240	1.244	.2149
DATA8	2.788010	.958805	.248028	2.908	.0040
(Constant)	179.229581	37.404024		4.792	.0000

------------- Variables not in the Equation -------------

Variable	Beta In	Partial	Min Toler	T	Sig T
DATA2	-.005216	-.004464	.414875	-.067	.9469
DATA4	-.060434	-.061184	.416036	-.915	.3610
DATA7	-.024777	-.027269	.404375	-.407	.6841
DATA9	.001059	.000836	.356824	.012	.9900

* *

Variable(s) Removed on Step Number 15.. DATA3

Multiple R	.55514	Analysis of Variance			
R Square	.30818		DF	Sum of Squares	Mean Square
Adjusted R Square	.29281	Regression	5	108851.30861	21770.26172
Standard Error	32.95481	Residual	225	244354.44031	1086.01973

F = 20.04592 Signif F = .0000

*** * * * M U L T I P L E R E G R E S S I O N * * * ***

Equation Number 1 Dependent Variable.. FITEM

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	T	Sig T
DATA10	1.213583	.707767	.096568	1.715	.0878
DATA1	1.649602	.874667	.110808	1.886	.0606
DATA6	-3.010328	.782702	-.236485	-3.846	.0002
DATA5	-2.014968	.793085	-.179506	-2.541	.0117
DATA8	3.421904	.813078	.304421	4.209	.0000
(Constant)	185.441720	37.113966		4.997	.0000

------------- Variables not in the Equation ------------

Variable	Beta In	Partial	Min Toler	T	Sig T
DATA2	-.030636	-.027189	.502546	-.407	.6843
DATA3	.094240	.082807	.421583	1.244	.2149
DATA4	-.075534	-.078279	.546041	-1.175	.2412
DATA7	-.021848	-.023980	.548442	-.359	.7199
DATA9	-.029206	-.024102	.406191	-.361	.7186

End Block Number 2 POUT = .100 Limits reached.

* *

Residuals Statistics:

	Min	Max	Mean	Std Dev	N
*PRED	124.8606	279.9839	201.1645	21.7547	231
*RESID	-111.7924	95.1593	.0000	32.5946	231
*ZPRED	-3.5075	3.6231	.0000	1.0000	231
*ZRESID	-3.3923	2.8876	.0000	.9891	231

Total Cases = 231

Durbin-Watson Test = 2.04921

APPENDIX K. Sample Student Interview

Mr. K.- Hello, student. My name is Mr. Krynowsky from the University of British Columbia. The idea behind this is to find out your thoughts and feelings about your attitude toward the subject science and the activities that go on in your science class. This information will be useful to all science teachers by giving them a better idea of the students point of view. So here is your opportunity to let people know how students look at the activities that go on in your science class. Please be honest and answer the questions to the best of your ability. Your answers will not be made known to anybody else. What I do is summarize , from all the interviews of students...I will do about 20 of them.. and I just summarize the main ideas of what the students are saying. If you do not understand a question ask me about it. Also, feel free to add any other comments related to the questions. If you have something to say feel free to do so. Any things about why you feel the way you do or any answers in which you want to add more detail feel free to do so. This should take about 10 minutes. Refer to the question sheet in front of you.

Mr. K- Okay my taking grade ten science as a school subject. If you were to give it a rating would you say its good or bad?

Student- Um, good, quite good.

Mr. K- Quite good, now what makes you say that?

Student- Some most of what we do is quite interesting, but some of it; some of it... I don't like its quite boring.

Mr. K- What do you find interesting and what do you find boring?

Student- Um, I like when we did pollution and stuff like that and um ...chemistry was boring.

Mr. K- Pollution you liked and chemistry you found boring. Now, how about your taking science as a school subject, do you find it useful or useless?

Student- Um, extremely useful

Mr. K- extremely useful

Student- No, no, quite useful

Mr. K- Okay thats fine. Ok, why do you think its quite useful.

Student- Well it depends on what your going to be going into. Like after university, if your going to be using it then its, its useful, ..But if your not using it well its not useful.

Mr. K- Well do you think its the career you choose

Student- Ya and its just having the knowledge

Mr. K- You find the career and having the knowledge as useful . Okay now how about you taking grade 10 science as a school subject.. Do you find it hard or easy?

Student- Um, I find it slightly easy.

Mr. K- What makes it slightly easy?

Student- I think if you study for it and listen and take notes.. Sometimes I don't like to pay attention.

Mr. K- But if you did study and listen?

Student- I would get a B quite easy then.

Mr. K- How about what do your friends think about taking grade 10 science as a school subject,..Do you think they find it good or bad ? ... The people you know taking grade 10 science..

Student- Um, I think they think , I guess,... Um, its slightly good. Well most of my friends.

Mr. K- Do you ever talk about grade ten science as a subject?

Student- Um, not really, just if we don't like what we are taking.... if we find it boring or not. I don't know.

Mr. K- So you say its tough for you to make a judgment on that question.

Student- Ya, we don't talk about it too much.

Mr. K- You must have better things too talk about

Student- Ya, thats right.

Mr. K- Most of my friends think that taking science as a school subject is useful or useless.. Now you've given your opinion, now what do most of your friends think...useful or useless?

Student- I think slightly useful.

Mr. K- Why do you think so?

Student- I think probably for the same reasons as before, for university, for the career.

Mr. K- Okay what do your friends think of grade 10 science being hard or easy?

Student- Um, I would say undecided because some of them are bored and it depends on how much they study. So some of my friends find it easy and some of them find it hard.

Mr. K- If you were going to put a phrase onto your opinion, as it stands ... about you taking grade 10 science as a school subject.... How would you complete that sentence?

Student- Um, I would like to take some time.

Mr. K- Sure, take as much time as you wish .....

Student- I think that it is good to take it, but I think ..well, they should make it more understandable. Somethings are....You have to define it better. I'm getting personal here but thats what I think. I'm quite a talker, ... but I listen.

Mr. K- So you think that it should be more understandable so that you can understand whats going on ?

Student- Ya, cause some of it , just some areas, ... they give notes you don't understand.

Mr. K- Now lets then look at something a little different. Now this is to ask you about what goes on in your grade 10 science class that makes you like or dislike grade 10 science as a school subject......Now like or dislike could mean what your fellow students do in class or what your teacher does.

Student- Now is this just going to be you .. or is anybody else going to see this?

Mr. K- No, just myself.

Student- Sometimes my teacher rambles on too much, like um,.....

Mr. K- Rattles on, you mean too much talking ?

Student- Not rattles on, I think sometimes what he talks about ...the lectures goes on too long. I think they should be just really clear and just get right down to the point.

Mr. K- Keep going..

Student- I like doing the labs.... like some of the labs are really good...like in the book. They are understandable and make sense. Um, I like the tests, like they are good. I think he does, Mr. X, gives good tests. They are not too hard and they are not too easy....like they are defined right.

Mr. K- Anything else?

Student- I think people talk too much in this class...like they don't listen to much to what he is talking about....and I have one more.

Mr. K- keep going....as many as you can come up with..anything thats constructive.. keep going.

Student- Ya, I like those projects we do.... they do help you.

Mr. K- What type of projects do you do?

Student- We do enhancement projects. They are a good idea. They get students into other areas they are interested in. Like they get..... they are free to pick a subject or topic.

Mr. K- Anything else you can think of?

Student- Not really.

Mr. K- Okay lets move on to the next question. If you were a grade 10 science teacher, and you had a class... What two things would you do in your class to help your students have a more positive attitude toward the subject science?

Student- Um, I think I would make everything more clear.. just clearer. ..What else, um...

Mr. K- Its your class and you want your students to have good or positive attitudes toward the subject science

Student- Okay, I'd be, I don't know how to say it... more of a disciplinarian sort of thing.. Um, just make them .. like show them you are the teacher sort of thing...like be quiet or stay quiet sort of thing. I would like some order in the class. Not that our teacher is that way, but its my opinion.

Mr. K- its your viewpoint that counts. Thank you very much student...It was nice of you to donate your time on such a nice day.

Student- Okay, good bye and good luck with your thing.

Sample Summary of Student Interview

CLASSROOM FACTORS THAT INFLUENCE STUDENT ATTITUDES TOWARD THE SUBJECT SCIENCE

INRODUCTION OF SELF(name,affiliation)

PURPOSE OF THE INTERVIEW

The purpose of this interview,which you have consented to,is to find out about your thoughts and feelings about both your attitude toward the subject science and the activities that go on in your science class. This information will be useful to all science teachers by giving them a better idea about the student's viewpoint.

Please be honest and answer the questions to the best of your ability. Your answers will not be made known to anybody else. If you do not understand a question please ask me about it. Moreover, feel free to add any other comments related to any of the questions.(eg. Why do you think or feel this way about your answer to the question)

Section A (Put an X in the space that best describes how you think or feel about the quest

1. MY TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

GOOD ....:....X.....:..........:..........:..........:..........:.......... BAD

extremely quite slightly undecided slightly quite extremely

WHY? most of it is interesting - depends on topic pollution I like, chemistry is boring

2. MY TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

USEFUL ....:....X.....:..........:..........:..........:..........:.......... USELESS

extremely quite slightly undecided slightly quite extremely

WHY? depends on my career choice and knowledge about the topic

3. MY TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

HARD ....;..........:..........:..........:....X.....:..........:.......... EASY

extremely quite slightly undecided slightly quite extremely

WHY? if you study and listen its easy.

4. MOST OF MY FRIENDS THINK THAT TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

GOOD ....:..........:....X.....:..........:..........:..........:..........BAD

extremely quite slightly undecided slightly quite extremely

WHY? We don't really talk about it

5. MOST OF MY FRIENDS THINK THAT TAKING GRADE 10 SCIENCE AS A SCHOOL SUBJECT IS

USEFUL ....:..........:.....X...:..........:..........:..........:.......... USELES
extremely quite slightly undecided quite slightly : extremely

WHY? for university and careers

6. MOST OF MY FRIENDS THINK THAT TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS

HARD :..........:..........:..........:...X...:..........:..........:.......... EASY
extremely quite slightly undecided quite slightly extremely

WHY? for some it is and some it isn't
-depends on how much they study

Please complete the following statement with a word or short phrase:

IN MY OPINION, MY TAKING GRADE TEN SCIENCE AS A SCHOOL SUBJECT IS good to take it but.

WHY? – should be more understandable

Section B (Please give your honest thoughts or feelings on the following questions:)

1. Could you please list five things that go on in your grade ten science class that makes you like or dislike grade ten science as a school subject:

a) Sometimes our teacher rattles on. Lectures are too long, should get to the point.

b) I like doing the labs (in the book)

c) I like the tests, not too hard and not too easy

d) Too much talk in class. Students don't listen

e) I like the projects we do for enrichment. Good when students are free to pick their topic

2. If you were a grade ten science teacher, what two things would you do in your class to try to make your students have positive attitudes toward the subject science?

a) Everything would be clear (explanations)

b) I'd be more of a disciplinarian. Order in class.

THANK YOU VERY MUCH FOR YOUR TIME AND COOPERATION!

Mr. Bernie Krynowsky
University of British Columbia

APPENDIX L. Summarized Student Responses to Interview Schedule

<u>1. My taking Grade 10 science as a school subject is good/bad why?</u>

-degree of interest/enjoyment-08

-extent to which the content is related to real life-03

-degree to which the science knowledge is useful-03

-its a requirement for future schooling/career-02

<u>2. My taking Grade 10 science as a school subject is useful/useless? why?</u>

-for career plans/getting jobs-07

-for understanding daily occurances-05

-for future high school/post secondary schooling-04

-depends on topic(some more useful than others)-02

<u>3. My taking Grade 10 science as a school subject is hard/easy? Why?</u>

<u>HARD</u>

-the mathematics(equations,formulas) in science -06

-too much memorization involved -04

-the chemisty section is difficult-04

-its boring to listen to-03

<u>EASY</u>

-if teacher is well organized/gives clear explanations-04

-if there is not too much work-02

-if there is labwork-02

-biology is easy-02

<u>4. My friends think that taking Grade 10 science as a school subject is good/bad? Why?</u>

-not sure because we don't talk about it-05

-depends on how well we get along in class-03

-it depends on what the friend's career plans are- 03

-it depends on what friend (it varies)-02

<u>5. My friends think that taking Grade 10 science as a school subject is useful/useless? Why?</u>

-depends on what careers/jobs they want to take up-06

-useful for future education-03

-it depends on the friend (varies)-02

<u>6. My friends think that taking Grade 10 science as a school subject is hard/easy? Why?</u>

-it depends on the abilities of the friend-04

-it depends on the amount of work/studying done-03

-it depends on the teacher you get-03

-it depends on the topic you are taking-02

The students from the sample were also asked to provide reasons as to what might give them a posisitve or negative attitude toward the subject science. One of the questions asked was: Could you please tell me about five things that go on in your science class that makes you like or dislike science as a school subject? Student responses were categorized and counted. The results of the categorization for both the like and dislike sections were:

LIKE(# of responses)

1. doing science labs/hands on activities/working with equipment-12
2. clear teacher explanations(easy to understand/well organized)-08
3. the teacher as a person-06
4. when the content we take is related to real life-05
5. the friends I have in class-04

DISLIKE

1. when the teacher talks too much(boring)-07
2. reading the science text-05
3. too many formulas and terms, too much memorizing-05
4. when the teacher lacks control of the class(too much student talk)-04
5. too much notetaking-04
6. the teacher as a person-02

The researcher also attempted to obtain further insights into other variables that students believed were important in terms of them having more positive attitudes toward the subject science. In order to obtain these insights , he asked students the following question: <u>If you were a Grade 10 science teacher, what two things would you do in your class so that your students would have a positive attitude toward your class?</u> The sample of students had the following responses:

1. more labs/experiments/hands on activities-05
2. well organized / clear explanations for students-04
3. less teacher talk and more student participation-03
4. good discipline/specific rules/students working-03
5. try to get along with my students(try to understand and have fun with them)-03
6. try to make the class fun to come to(share jokes/variety of things to do)-03
7. have more science content related to everyday life-02
8. have students be able to choose some topics that they would like to learn about (e.g. project work)-02
9. have interesting audio-visuals brought into class-02

The Nature of Science

A unit of instruction for Grade 10

Bernie Krynowsky, 1986

"They don't give us time to learn anything; we have to listen to the teacher all day."

Table of Contents

POSSIBLE UNIT PLAN

GENERAL TOPIC/SUBTOPICS

Nature of Science (how science operates in society and process skills of science).

MAJOR CONCEPTS TO BE LEARNED

1. Science is one way of knowing about the universe
2. Science is a human activity that can be done by ordinary individuals
3. Science knowledge can be learned through involvement in activites which emphasize group interactions and enjoyment of the subject.
4. Science knowledge can be related to everyday problems and issues
5. There are many ways to investigate problems in a scientific way.
6.

SPECIFIC OBJECTIVES

1. Students will improve their scores on the Nature of Science Quiz and the Attitude Toward the Subject Science Scâle.
2. Students will critically analyze experimental designs and
3. Students will design and carry out an experiment to test the difference between two products.
4. Sudents will identify four characteristics of the nature of science in both soving a puzzle and in a problem soving situation.
5. Students will carry out an experiment and collect data upon which conlusions about the limits of scientific knowledge will be made.
6.
7.

TIME FRAME(# of lessons, dates, contingency)
10 one hour lessons

PREREQUISITE KNOWLEDGE(what has to be reviewed)
- Could be an introductory unit to the program
- Review of the concept of what science is and does

OPENER (exciting introduction)
- discrepant event or events demonstrated by teacher

ENDER (how will this unit tie into the previous and succeeding units)
- design and analysis of investigations to test consumer products

1. INTRODUCTION

1.1 GENERAL GOALS

The general goals of this science unit are to:

a) improve student attitudes toward the subject science by attempting to increase student satisfaction with the work of the class

b) increase student knowledge about the nature of science (i.e. how science operates in society)

1.2 BACKGROUND

Research has shown that teachers have had difficulty in terms of defining what an attitudinal objective means, knowing how to teach for it, and obtaining an indication of whether or not their teaching had any attitudinal effects. The major purpose of this unit is to assist teachers in their teaching for improved student attitudes toward the subject science by suggesting how these attitudes could be defined, taught for, and evaluated.

1.2.1 ATTITUDE DEFINITION

Teachers likely have many different ideas of what positive student attitudes toward the subject science are. For example it could mean a like of the subject matter, an appreciation for the role of science in society, or feelings about the class. These many ideas make your job more difficult in terms of what you can do to improve these attitudes however they have been defined.

An alternative to this confusion is to have a more precise definition of attitude so that you can better focus your teaching. What is proposed is the following definition:

A positive student attitude toward the subject science is a learned predisposition of your students to evaluate, in a consistently favorable way, specific behaviors they are asked to do in the learning of the subject. In plain English, what you attempt to do is to have your students evaluate the things done in the teaching/learning of science in a positive way. For example in the course of your teaching you ask students to read the text, watch a video, or to perform an experiment. What you therefore attempt to achieve in terms of your attitudinal goal, is to have your students positively evaluate as many of these behaviors as possible.

1.2.2 TEACHING FOR POSITIVE ATTITUDES

Given that you desire positive evaluations of these behaviors, the big question is likely how can this be done. Some ideas are provided in this unit. These ideas are based on a research study which investigated relationships between student attitude toward Grade 10 science and classroom learning environment variables. In this study it was found that student attitudes toward the subject were influenced by the extent to which students were satisfied with the work done in class. Further, based on an interpretation student interviews it was found that satisfaction could be improved if there:

1. are many labs/activities (minimal reading of the text)
2. are clear well organized teacher explanations
3. good interpersonal relationships within the class

Given these findings the focus of this unit is to try to have your students believe that the learning of the subject science is an enjoyable experience and that the outcomes of participating in activities, having good personal relationships, and experiencing well organized lessons are positive.

One of the ways to influence these beliefs, which in turn may lead to more positive attitudes, is to provide information to students. This information could be both explicit or implicit. Implicitly, the nature of the work selected is such that new experiences are introduced which may positively influence student beliefs about the work done in class. Explicitly you can, in both a verbal and non-verbal way, communicate to students the consequences of performing/not performing specific behaviors associated with the lessons in the unit. An example of explicit information which could be presented is given below:

Sample Information

Active Participation/Minimal Reading of Text

Active participation in class activites is very important to your doing well in this class. A significant (e.g. 20%) percentage of your final mark will be based on my judgment of how well you participated in the labs and activities in this unit. The class activites/labs are structured so that if you participate in the activity you will have very little or no homework to do. Further, the examination at the end of this unit be based almost entirely on questions you were required to answer during the activities. In short, I believe if you participate in the activites to the best of your ability you will do reasonably well in the unit and the course.

There are other reasons why participating in the activites is important. Doing these activites will allow you the opportunity to develop skills that may be useful in future life. For example, you will have opportunities to be improve your abilities in: problem solving, organization, observing, predicting, and communicating. Further, some of the activites are related to helping you become a better consumer and judge of what you are exposed to in the media. These skills may also be of use to you in the search for employment whereby they are expected by prospective employers.

Good Personal Relationships

This unit is designed so that you will have the opportunity to interact with both other students in the class and the teacher. Being able to get along with others is a very important part of your future life. The way you interact in this class is important in terms of the friends you have and make and the enjoyment of learning science.

There are also other reasons why it is important to have good relationships in this class. For example, because teachers are human, they tend to give students the benefit of the doubt in situations for students who at least try to get along. Further, teachers also consider this factor when they write up your report card or talk to your parents. In the area of employment, many employers judge not your education or experience but how well they believe you will fit in with other employees. It is important, therfore to try and get along and cooperate with both your fellow students and teacher. This unit of instruction could represent a test for you to see if you need to improve in this area.

This unit will also allow you to share your own experiences and knowledge with others in the class. This sharing is such that we can learn from each other and enjoy each others company as well as make learning more interesting. In short, if we can get along, the class will be more fun and will help you in future life.

Organization of the Instruction

The lessons in this unit consider different ways in which to learn some stuff. In this case the stuff is about how science and society interact. Each lesson will have a specific purpose which will be made known to you.

During the actual lesson you will be asked to do various things. It is to your advantage, because 20% of your grade in this unit is based on how well you are judged to participate, to keep careful note of the instructions and tasks. Further, the lessons have been organized so that you will not have much idle time, which should mean you will be less bored with the class. The lessons are also organized to let you check if you understand what is being done. Please let the teacher know about any problems you have with following what is going on. Remember, that you will be doing assignments for most of the activities. These assignments will be gathered in and corrected at the end of the unit. Given, the organization of this unit you may wish to keep your books and assignments up to date and corrected.

1.2.3 ATTITUDE ASSESSMENT

Given the general model of how your attitudinal goal could be defined and taught for, it may be of interest to know whether or not student attitudes toward performing behaviors associated with the unit were positive. Within this unit is a measure, the Attitude Toward the Subject Science Scale, which will provide you with some feedback on the attitudes of both your class as a whole as well as individuals in the class. Further, this measure is based on the definition of attitude which was used as the frame of reference for the attitudinal goal. A sample copy of this measure and directions for its scoring are located in the Appendix of this unit.

1.3 ORGANIZATION OF THE UNIT

The unit consists of a series of 10 lessons which deal with some of the process skills and knowledge of science as it may operate in a societal context. Each of these lessons includes some suggestions for how the lesson could be carried out as well as the supporting materials required. Further, these lessons could also be supported with appropriate material found in science textbooks. Those materials found in science textbooks will be referenced while those of unknown origin will be included in this unit.

In conjunction with the lessons, there are evaluative measures included which could help you determine whether or not the unit has met its general goals (i.e. improved attitude toward the subject, greater knowledge of the nature of science, more satisfaction with the work of the class). These evaluative measures are included in the appendix of the unit.

2. LESSONS

2.1 LESSON ONE-- INTRODUCTORY LESSON --

In this lesson, the major concepts to be taught and a rationale for the unit could be provided. Students could be asked to note these concepts. The rationale could be based on the arguments for improving satisfaction previously suggested. After this discussion, it is possible to assess student present attitude toward the subject science using the Attitude Toward the Subject Science Scale. This scale, along with its scoring instructions, is located in the Appendix. Further, you can also assess student present knowledge about the nature of science using the Nature of Science quiz. This assessment is also located in the Appendix. As a finale to the lesson you can leave students with a problem of the magic comeback can. This problem is intended to create interest about how science attempts to explain and describe phenomena in the universe.

Teaching Hints

The discussion of the concepts to be learned should be brief. Indicate that periodically these concepts will be reviewed in the context of activities to be done.

The ATSSS takes about 12 minutes for students to complete including a review of the instruction page which should be done with the class. Students should be reminded that no marks are associated with this assessment but rather it is being used by you to see how students view the subject science.

The Nature of Science Quiz (NOS) takes about 20 minutes to complete. The purpose of this assessment is to determine student knowledge about how science operates in society.

Both the ATSSS and NOS can serve as pretests to determine how well your lessons achieved their general goals. The NOS may also abe used as a summative evaluation in terms of assessing student knowledge about the nature of science or as a teaching strategy whereby the items can be reviewed and corrected in class.

The Magic Comeback Can is a discrepant event which is intended to stimulate student interest and questioning regarding an explanation of why the can comes back. Teachers can follow the suggested guidelines of how these events can be presented.

Support Materials

- How to present discrepant events (Liem, 1981, pp 1-5)
- Comeback Can (Liem, 1981, p. 277)

2.2 LESSON TWO -- NATURE OF SCIENCE--

This lesson is primarily intended to review some of the generally accepted principles about how science operates in society. Included in this lesson are reviews of some of the definitions of science and suggestions for why the can came back.

Teaching Hints

The lesson could begin with a review of what was done last day. Further, you can ask students to be prepared to try to answer the problem of why the can came back. These possible answers could be discussed at the end of class in the context of some of the principles of the nature of science.

Students should be given the opportunity to define what "science" is and does. Have them write down their definition. Ask for student responses which can be recorded on the board or overhead. Handout "Definitions of Science" which summarizes some of the key notions of what science is and does. Briefly discuss these definitions and how they vary or are the same.

After the discussion, hand out "A Few Key Concepts About the Nature of Science". Discuss these key concepts. Try to provide examples of these general principles. Further, discussion of the exceptions to these principles and student experiences with science as a subject or influence on their daily lives should also be included.

As a concluding part of the class ask for student ideas about why the can came back. Have students record these ideas in their books. Expand on some of the general principles of the nature of science in the explanation and description of this event. For example, one could attempt to evaluate the adequacy of the explantion given for the event, the way this knowlegde was obtained, the applications of this principle in technology etc...

Assignments

1. Students could select one definition from those given and attempt to defend their selection in two written paragraphs.
2. Students could be asked to record two general principles about the nature of science that the comeback can illustrated.

Support Materials

- Definitions of Science
- A Few Key Concepts (Nature of Science)

DEFINITIONS OF SCIENCE

1. Science is nothing else than the search to discover unity in the wild variety of nature--or more exactly, in the variety of our experience. J. Bronowski, "Science and Human Values."

2. Science is an accumulated and systematized learning, in general usage restricted to natural phenomena. The progress of science is marked not only by an accumulation of fact, but by the emergence of scientific method and of the scientific attitude. The Columbia Encyclopedia, 3rd Edition.

3. Science is an interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observation and are fruitful of further experimentation and observations. James B. Conant. "Science and Common Sense."

4. The object of all science is to coordinate our experiences and bring them into a logical system. Albert Einstein.

5. The task of science is both to extend the range of our experience and to reduce it to order. Neils Bohr.

6. Science is man's attempt to explain natural phenomena. Duane Roller.

7. Science is the investigation and interpretation of events in the natural physical environment and within our bodies. Willard Jacobson.

8. Scientists are primarily discoverers and interpreters of information about nature. National Society of Professional Engineers.

9. A scientist is a person who must have the primary goal of understanding nature and enlarging knowledge without regard for any immediate practical use. American Society of Civil Engineers.

10. Science, broadly defined, is the sum or essence of what those who are generally recognized as scientists and those who study scientists say it is; in addition, it is what these scientists do when they practice their profession.

A FEW KEY CONCEPTS - "NATURE OF SCIENCE"

1. Science, is mans' attempt, at organizing and explaining natural phenomena in the universe. There are numerous other definitions of science which often consider a) knowledge generated b) methods used to find this knowledge. Curiosity about the universe is the primary driving force for scientific activity.

2. Science creates useful theories, laws, (explanations) that work. These theories change with new observations, new technologies, or new knowledge about the universe. Nothing is ever completely proven in the universe.

3. Science attempts to improve upon its explanations. These explanations are often reduced to a mathematical language. There is always a degree of error in measurement.

4. There is no one "scientific method" as is often described in school textbooks. Rather, there are many methods of science as there are many different problems and investigators. Scientific methods can be used in daily living. (skills and processes)

5. The methods of science have a few attributes which are in the realm of values rather than techniques. These include a) dependence on senses b) setting up definitions or classifications c) making certain assumptions d) evaluation of scientific work of others. Science and technology are human endeavors subject to human failings.

6. Science cannot explain all events, it has its limitations. Moreover, methods of science are not appropriate for all forms of knowledge. There are many ways to describe, explain and organize our universe other than scientific ways. (philosophical, psychological, religious)

7. The activity of science (search for knowledge) is related to technology (application of knowledge). Both these endeavors affect our social, political, and economic situation. Science is often influenced by cultural expectations and bias.

2.3 LESSON THREE-- PUZZLE --

This lesson is intended to provide an analogy between the putting together of a puzzle and the way scientists create and communicate their knowledge.

Teaching Hints

In this activity students are asked to play the role of a scientist who is given only a portion of a puzzle. The problem they are faced with is to arrive at a description of the puzzle.

Purchase 3 identical or different puzzles and assemble them. The puzzle should have an interesting theme and include about 120 pieces. Divide the puzzle into five sections. Each of these sections should be placed in separate containers or bags for future use. Follow the directions outlined on the activity sheet. Select one person from each group to describe their version of the puzzle.. Display the cover box picture as the description is being made.

Assignment

1. Ask students to list 4 principles about the nature of science suggested by this activity. Discuss these principles.
2. Handout "Science: A Way of Knowing" article. Ask students to summarize two key ideas from this article.

Support Materials

-Puzzle Solving

-Science: A Way of Knowing (Aikenhead & Fleming, 1975, pp. 01-02)

PUZZLE SOLVING (NATURE OF SCIENCE)

You will be part of a team of scientists who are given a problem (puzzle) to solve. Unfortunately, you will only have a small part of the puzzle. Your objective is to work with other scientists in your team in order to produce the best possible solution to the problem (i.e. describe the puzzle). The class will be divided into 3 teams of scientists, each with a different puzzle. What you attempt to do is contribute as much information as you can to your team so that it will have the best description of a puzzle.

DIRECTIONS

1. Teacher will divide class into teams of scientists (10 scientists/team)
2. Teacher will send each team to a specific place in the classroom
3. These teams will be divided into subgroups with 2 scientists/subgroup
4. Each subgroup will be given a portion of a puzzle. Note; the puzzle would be complete if each subgroup put their sections together
5. Put your section of the puzzle together. (5 min)
6. Each subgroup will prepare detailed notes (data) which may provide clues to what the puzzle is about. (Time - 5 minutes)
7. Each team will meet in an assigned part of the room. Each subgroup can only bring their notes on what they observed in their section of the puzzle. At this meeting each scientist is asked to record, in their books, the following information: (Time - 20 minutes)

Team Name ________________

PUZZLE SOLUTION

	Information	Inference
Group 1		
Group 11		
Group 111		
Group 1V		
Group V		

Your description:

Each scientist is also asked to record in their books an answer to the following question: What are 4 general principles about the nature of science revealed in the puzzle activity? (You may refer to your previous notes)

2.4 LESSON FOUR-- SCIENCE: A WAY OF KNOWING --

This lesson is intended to examine the nature of knowledge as presented in a scientific way. The main objectives of this lesson are to present some "main ideas" about the scientific way of looking at the world and the limitations of this knowledge. This way will be examined in terms of having class discussions about science and doing an investigation in order to appreciate the limitations of scientific knowledge.

Teaching Hints

Remind students (e.g. using a question about what was done last day) of the fact they have been given some information on the nature of science in society. This lesson is to expand on this information through the use of discussions and an activity. Ask students to answer the question of what two main ideas of the article on science were. Have individual students read, in turn, two to three sentences of the article. After it has been read, briefly summarize these key ideas. Discuss the questions indicated in the article.

The second part of the lesson involves a closer look at the limitations of this scientific knowledge using an activity called "Stretch and Extrapolate". For this activity follow the guidelines indicated. Groups of two or three students work best. Help students as required.

Assignment

Ask students to complete the questions indicated on the activity sheet. These may be answered individually or as a group.

Support Materials

- Science: A Way of Knowing (Aikenhead & Fleming, 1975, pp. 01-02)
- Stretch and Extrapolate (Aikenhead & Fleming, 1975, 9D3-9D6)

2.5 LESSON FIVE-- PRACTISE IN ANALYSIS OF INFORMATION --

This lesson involves an analysis of the investigation "Stretch and Extrapolate" as well as the opportunity for students to practice further science skills of analysis and experimental design. Teaching Hints

The first part of the class could begin with an analysis of the answers to the questions on "Stretch and Extrapolate". Ask students to improve or add to the answers they had given.

Relate the activity of extrapolation to the skills which help individuals to find knowledge in a scientific way. Tell students that this lesson will involve the practice of some of these skills critical analysis and experimental design.

Have students read "New Elements" silently. Ask them to record four main ideas about how science knowledge is gained. Discuss these main ideas.

After this activity, have students work in groups of two in order to help each other design and critically evaluate "Which Side is Up?" There may be a need to review some of the main ideas of how and why experiments are designed and the problems involved carrying them out. Discuss the evaluation of the experiment and how it relates to the article on the new elements.

Assignment

Ask students to list three questions they could ask about the claim that "9 out of 10 dentists recommend Trident for those people who chew gum"

Optional Assignment Additional Credit. "The Mysterious Killer". This activity delves deeper into an analysis of how scientific skills/methods work.

Support Materials

- Physicists Report Six New Elements
- Which Side is Up? (Nay, 1982, p. 17)
- The Mysterious Killer (Nay, 1982, pp.12-16)

PHYSICISTS REPORT SIX NEW ELEMENTS

TORONTO, ONT. (AP) -- Scientists at the University of Toronto say they have discovered three and perhaps six new natural elements -- the first new ones in 51 years.

Using a sophisticated particle accelerator, the team of physicists said recently it found the new elements to be super-heavy, weighing more than uranium.

Elements, such as oxygen, cooper and sulphur, constitute the fundamental building blocks which alone or in combination with other elements make up matter.

The new elements were found in minute quantities in clumps of mica rock discovered by Dr. Robert Gentry of the Oak Ridge National Laboratory in Tennessee, the scientists said.

Dr. Alex Zucker, associate director at Oak Ridge, said it is too soon to confirm the findings.

"From time to time, this hunt looks like it's going to bag something. Usually these hopes turn out to be ephemeral." he said.

However, Dr. William Nelson, British physicist on the team, said he is confident new elements have been found because the scientists have been able to photograph the structures using x-rays.

"The x-rays are the final court of appeal," he said. "We have the confidence in our measurements or we wouldn't have released them."

Dr. Thomas Cahill, a visiting professor from the University of Manitoba, first announced the discovery at a scientific meeting in Quebec City recently.

Cahill said he recognizes more work will have to be done before the scientific community will be convinced of the authenticity of the team's findings.

The last natural element, rhenium, was found in 1925 in Germany.

This article should tell you some things about science and scientists. Try to list (5) possible facts about the nature of science from this article.

2.6 LESSON SIX --SCIENCE AND PROBLEM SOLVING --

This lesson is intended to be a enjoyable activity in which there is an opportunity for students to work as both individuals and a group in order to solve problems presented to them. The source of this lesson is from Dr. Ken Weber who used these problem solving exercises to help special needs students.

Teaching Hints

The first section of the problem solving involves the presentation of a situation to which there are many possible solutions. Explore these possible solutions and propose ones that seem most plausible. Ask individual students to read the information preceeding each set of problems. Briefly comment on the main ideas.

Students could be shown how to organize information in grids so that the second section could be answered in a more systematic way. Have students try at least two problems from this section. You can ask for those who believe they have the correct answer to raise their hands so that they can check them. Further, you can have a student who obtained a correct answer to explain how they got it to the rest of the class.

The third section consists of messages hidden in a box. Give students the answer to one of the messages as an example. Let students work through the messages with the challenge of trying to get as many as possible. You can award small prizes for the most or least correct, or creative message.

Assignment

Ask students to prepare their own message in a box for next class along with the answer. Collect these messages and put them on the bulletin board. Challenge students to find as many of the messages as possible.

Support Materials

- Science Thinking and Problem Solving

SCIENCE, THINKING, AND PROBLEM SOLVING

One of the most important skills of a scientifically minded person is that of logical problem solving. Throughout life we are faced with problems or situations with which we must deal. Therefore, it is important to develop these skills for your future benefit.

Exercises: Develop your ability to find possible answers to a problem.

1. Mr. Roger Adams stepped off the train in Saskatoon and met a friend he had not seen in years. Beside his friend was a little girl. "Roger!" shouted the friend. "How delightful to see you! Did you know that I have married? This is my daughter."
   "Hello," said Adams to the little girl, "what is your name?"
   "Same as my mother's," replied the girl.
   "Then you must be Anne," said Adams.
   How did he know?

2. Carol and Mary Jones were both born just before midnight on October 10, 1871. They had the same parents, Mr. and Mrs. Cleve Jones. Yet even though they had the same parents and were born at the same time, they were not twins! Can you explain this?

3. Erica drives a taxi. She likes her job but she hates passengers who talk. Whenever passengers begin to talk, Erica points to her ears and mouth, and shakes her head. Her passengers usually believe that she is deaf and dumb and stop talking. Only when they arrive at their destinations do they realize that they have been fooled. How?

In order to solve problems there are certain methods that can be used to make it a logical process. This is very similar to the different scientific methods you have used to investigate problems. Moreover, you use the same skills and attitudes of a scientifically minded person. (eg. organize, record, analyze, conclude, curiosity, open mindedness, determination, caution).

Thinking Skill: how to organize data.
It is important to organize your work to solve the problems.

After the revolution in Labonia, the old king, his chief of police, and the general of the army were tried in court.

The judge said to the old king, "If both the chief of police and the general receive the same sentence, you will be executed." To the police chief, the judge said, "If the king and the general receive the same sentence, you will be imprisoned." The judge said to the general, "If the other two receive different sentences, you will be set free."

Then the judge pronounced sentence. "Tomorrow at dawn, one of you will be set free, another will be improsoned, and the third will be executed."

What happened to each of the prisoners?

DEDUCTIVE AND INDUCTIVE THINKING

Much of good thinking depends upon common sense, and upon using the evidence available. In science most of our thinking is of the inductive variety whereby we make conclusions based on past experiences and observations. However, we also use some deductive thinking which is basically mathematical logic. It is important to be able to use logical thought which is based on thinking "reasonably" and making conclusions based on "evidence".

Problems

1. Harold, Inez, Maria, and Rajit are 8, 10, 12, and 14 years old, but not necessarily in that order.

   Maria is older than Rajit but younger than Harold.
   Inez is younger than Maria but older than Rajit.
   What is each persons age?

2. Bette, Andre, Silvio and Mai-Ling are in the annual school play, as a salesperson, a plainclothes detective, a technician, a taxi driver.

   The director is very pleased with the way that Andre, Silvio, and the salesperson are doing their quarrel scene.

   Mai-Ling, Andre and the technician are under surveillance in the first act.

   Everyone but the detective has a speaking part.
   Who plays what role?

3. Dinah, Cathy, Luis, and Ned each have been given a lucky number in a lottery. The numbers are seven, four, two, and twelve.

   One of the boys has the number two.

   Cathy and the girl who has the number four are on the swimming team.

   No one's name has the same number of letters as there are in his or her lucky number.

4. Four cars are parked in reserved spaces 21, 22, 23, and 24 at Acme Think Tank Co. The cars are grey, red, white and yellow.

   The yellow is not in 21.

   The red is between the grey and the white.

   The grey is between the yellow and the red.
   Which car is in which spot?

DEVELOPING IDEAS (Brainstorming)

Quite often in your interactions with other people you interchange ideas and opinions. Science attempts to generate new ideas (knowledge) that help explain natural phenomena. Therefore, this activity of "idea generation" is important for personal relations as well as the generation of new knowledge.

1. Warm Up Activity (exercise for the mind)

DETERMINE THE WORD OR MESSAGE IN EACH BOX					
1 T O U C H	2 MOTH CRY CRY CRY	3 BLACK COAT	4 TIME TIME		
5 L A N D	6 HURRY ↑	7 ME QUIT	8 LE VEL		
9 MAN BOARD	10 HE'S / HIMSELF	11 R ROAD A D	12 ZERO M.A. B.A. PH.D.		
13 WEAR LONG	14 CYCLE CYCLE CYCLE	15 CHAIR	16 T O W N	29 R/E/A/D/I/N/G	30 KNEE LIGHT
17 STAND I	18 JACK	19 Ba ck	20 ABCDEF GHIJK MNOPQR STUVWXYZ	21 S P E L L	28 UNDER
22 STOP	23 Y A R C S	24 PLAY PLAY PLAY	25 BLUE ALL ALL	26 Border | case	27 AGENT

2. Given an unlimited budget, unlimited authority, and unlimited technology, what <u>five</u> improvements would you suggest to improve this school <u>or</u> classroom.

3. List (10) specific outcomes on earth of 6 months total darkness followed by 6 months of total lightness.

2.7 LESSON SEVEN-- SPACE CONSENSUS --

This lesson continues the theme of involving students in activites which emphasize participation and use of science skills. In this lesson students will be placed in a problem solving situation where they are challenged to make some decisions about items which are or not important for their survival. The consensus originated from training materials at NASA whereby, astronauts were given similar problems to solve.

Teaching Hints

The lesson consists of three parts. The first part inovlves briefly reviewing some of the current events in space exploration and its impact on society. Further, there may also be a brief review of some of the major concepts in terms of characteristics of the moon/earth in space.

The second part involves the completion of the consensus form individually after the instructions have been reviewed. Do not help students just check to see they are on task. The completion takes about 15 minutes.

The third part involves the selection of captains and crews who are told they must decide on only one list of items. The captains can be selected at random and given a number. Crews can be selected by by numbering of the students. Move about the class to listen in on some of the interesting comments. Do not help students just check to see they are on task. Allow 20 minutes for completion of the consensus.

At the end of the class tell students that the answers they provided will be checked with the answers the astronauts gave. Further, there will be small prizes for the best astronaut and best crew.

Support Materials

- Space Consensus Form and Answers

Name: Mr. Bernie Krynowsky

Address: Perdue School,
Perdue, Sask.

Lesson Grade Level: 8-12

Topic: The Universe
Problem Solving

Space Consensus

Plan Outline

Objectives:
- Problem solving practice
- Knowledge about moon revealed
- Group interaction developed

Materials: Consensus Form. (Answers from astronauts)

Procedure:

Read the directions on the form to the students. Allow 20 minutes for individuals to complete the form. Divide the class into space crews of 4 - 6 people. Have the crew complete one form. Compare individual and crew answers to those of the astronauts who actually took the same test. Discuss the reasons for the answers in class. The total number of differences between astronaut answers and the individuals is the score.

Outcome

Students will encounter a problem situation which they must think through. Moreover, they will learn some scientific facts about the universe. The group interaction is good leadership experience in a class setting.

First Section (to be taken by individuals)

Instructions:

You are a member of a space crew originally scheduled to rendezvous with a mother ship on the lighted surface of the moon. Due to mechanical difficulties, however, your ship was forced to land at a spot some 200 km from the rendezvous point. During re-entry and landing, much of the ship and the equipment aboard was damaged; and, since survival depends on reaching the mother ship, the most critical items available must be chosen for the 200 km trip. Below are listed the 15 items left intact and undamaged after landing. Your task is to rank order them in terms of their importance for your crew in allowing them to reach the rendezvous point. Place the number 1 by the most important item, the number 2 by the second most important, and so through number 15, the least important.

____ Box of matches
____ Food concentrate
____ 20 meters of nylon rope
____ Parachute silk
____ Portable heating unit
____ Two .45 calibre pistols
____ One case of dehydrated Pet Milk

_____ Two 50 Kg. tanks of oxygen
_____ Stellar Map (of the moon's constellations)
_____ Inflatable raft
_____ Magnetic compass
_____ 12 litres of water
_____ Signal flares
_____ First aid kit
_____ Solar-powered FM receiver-transmitter

Answers for Pages 13 and 14

Key - Astronault Answers

15	Box of matches	no 0_2
4	Food concentrate	requirement
6	20 meters of nylon rope	climbing
8	Parachute silk	shield from sun
13	Portable heating unit	heated side (not needed)
11	Two .45 calibre pistols	propulsion device
12	One case of dehydrated Pet milk	too bulky
1	Two 50 Kg. tanks of oxygen	requirement for life
3	Stellar Map (of the moon's constellations)	finding directions
9	Inflatable raft	CO_2 for propulsion
14	Magnetic compass	no magnetic field
2	12 litres of water	requirement
10	Signal flares	possible assistance
7	First aid kit	health
5	Solar-powered FM receiver-transmitter	possibility of calling

SURVIVAL SCALE (scores)

1-10 excellent
10-20 very good problem solver
20-30 good
30-40 made it but crawed in
over 40  funeral on the moon

2.8 LESSON EIGHT--COMPLETION OF SPACE CONSENSUS AND CONSUMER CONCERNS--

This lesson consists of two sections. The first involves the completion of the space consensus, the second involves an introduction to the use of methods of science to check out the quality of products.

Teaching Hints

For the first part ask students to have their space consensus forms in front of them. Review the scoring system with them. They are asked to add the differences between what they put down and what the astronauts put down. Captains are asked to score both their own and their team forms. Question students on the importance of each of the items and allow them to identify some facts about the earth/moon/space. Allow 10 minutes for the completion of questions. Review possible responses.

The second part of the class involves a brief presentation about how science methods are sometimes used to help consumers make better decisions about products in the marketplace. Have copies of consumer books for students to examine. Also allude to programs on television which do some testing of products (e.g. Live it Up; Marketplace). Ask students to record in their books what methods are used. Tell students that next day they will watch segments of two shows that evaluate products.

Assignment

Hand out "How to Be a Thinking Consumer" (Andrews, 1982 pp. 238-240). Ask students to list two main ideas this article conveyed.

Support Materials

- Space Consensus Answers
- How to Be a Thinking Consumer (Andrews, 1982, pp.238-245)

2.9 LESSON NINE-- DESIGN OF PRODUCT TESTING --

This lesson consists of two parts. The first involves the viewing of segments of a products testing situation; the second involves the design of a hypothetical experiment to determine if seat belts work.

Teaching Hints

Show the segments of the show. Ask students to find weakneses in the design of the tests viewed (e.g. variables not controlled, limitations of the conclusions, equipment needed for the testing). Discuss these limitations in class.

The second part invovles the presentation of a problem of whether seat belts work. Discuss the political, social, economic and religous impact of this problem. Walk students through some of the considerations used in the design of scientific experiments. Have students record these major considerations (e.g. clear definition of problem, collection of data ....). Background information is included in the support materials (use considerations outlined in consumer article).

Tell students that next day they will be asked to design a experiment and actually try to determine which paper towel has the most absorbancy or which dishwashing detergent is the most effective.

Support Materials

- Refer to How to be a Thinking Consumer (Andrews, 1982, pp. 238-245)

2.10 LESSON TEN -- DESIGN OF EXPERIMENT --

This lessons is intended to allow students the opportunity to design an investigation to determine the "best" paper towel and the "most effective" dishwashing detergent.

Teaching Hints

Have the materials necessary to conduct both investigations. Allow students to work with a partner who can help design the experiment and organize the materials to do the testing. Do not tell the students how to design the experiment. Allow them the opportunity to explore the possibilites for the design. If students finish one experiment they may be allowed to try the other. Some background information is available in the support materials.

Assignment

1. Ask students to make a report on their design and results of the investigation. It should be make clear that this report will be evaluated on a scale of ten for the following criteria: the effectiveness of how well the experiment was carried out; the replicability of the experiment; the way in which data was reported, additional information presented (e.g conclusions, sources of error).
2. Chose at least one of the investigations suggested in the article for additional credit or for those who are interested. (p. 245)

Support Materials

How to be a Thinking Consumer (Andrews, 1982, pp. 238-245)

Concluding Comments

The preceeding unit on the nature of science was intended to improve both student knowledge about the nature of science and student attitudes toward the subject science. The premise behind how these attitudes could be improved was that if one could improve student satisfaction with the activities of the class they would be able to improve these attitudes. Further, it was inferred that teachers could increase satisfaction by convincing students that there were positive outcomes in performing behaviors that are related to the teaching/learning of the lesson/unit/subject.

It is possible to perform retests on student knowledge about the nature of science, student attitudes toward the subject, and student satisfaction for specific activities using the instruments included in the Appendix.

References

1. Andrews W.A. (1982). Discovering Physical Science. Scarbourough Ont: Prentice Hall.

2. Aikenhead, G. & Fleming R. (1975). Science: A Way of Knowing . Unpublished draft of curriculum project. Univ. of Sask.

3. Liem T.L. (1981) Invitations to Science Inquiry. Lexington Mass: Ginn Custom Publishing.

4. Nay, M. (1982). How to Teach Hypothesizing and Inferring and all that Process Stuff. International Science Conference Presentation, Saskatoon Saskatchewan.

ATTITUDE TOWARD THE SUBJECT SCIENCE SCALE

Please do not turn the page until you are asked to do so.

SCHOOL ______________________ SCALE NUMBER __________

PURPOSE

The purpose of this scale is to find out your overall thoughts or feelings toward the topics and activities within the science course you are taking this school year. You will be asked to respond to some statements about activities related to this science course. Please respond to all of the statements honestly and to the best of your ability. This is not a test. Your answers are confidential.

INSTRUCTIONS AND EXAMPLE

Instructions

1. Read the statement carefully.
2. Note the words at the opposite ends of the scales given to you. Pick the word from the end of each scale that best describes how you think or feel about the activity in the statement.
3. Put an X in one of the labelled spaces at the end of the scale that you picked. This X shows how strongly you think or feel about the activity in the statement.

Example

Here is an example of a statement and one scale which has been responded to:

MY READING A SCIENCE RELATED MAGAZINE ARTICLE IS

BORING ______ : ______ : ______ : ______ : ______ : __X__ : ______ INTERESTING

BORING	extremely	quite	slightly	undecided	slightly	quite	extremely	INTERESTING
						X		

In this example, the X placed in the quite space on the INTERESTING end of the scale shows that the person responding to this statement thinks or feels that the reading of a science related magazine article is quite interesting.

4. Work rapidly, and give your first thought or feeling about the activity in the statement. Please remain quiet until everyone is finished.

REMEMBER

*THERE ARE 3 SCALES PER STATEMENT. RESPOND TO ALL OF THE STATEMENTS AND SCALES.

*ANSWER HONESTLY AND TO THE BEST OF YOUR ABILITY.

*THIS IS NOT A TEST. YOUR ANSWERS ARE CONFIDENTIAL.

ARE THERE ANY QUESTIONS? ....YOU MAY BEGIN

ALL OF THE FOLLOWING STATEMENTS ARE RELATED TO YOUR SCIENCE COURSE <u>THIS SCHOOL YEAR</u>.

Please respond to all <u>three</u> scales for each statement.

1. MY READING THE SCIENCE TEXT AT LEAST ONCE A WEEK IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
PLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	UNPLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

2. MY ACTIVELY PARTICIPATING IN MOST OF THE LAB ACTIVITIES IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
PLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	UNPLEASANT
NICE	extremely	quite	slightly	undecided	slightly	quite	extremely	AWFUL

3. MY WATCHING A T.V. PROGRAM ABOUT SCIENCE AT LEAST ONCE A MONTH IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

4. MY TRYING MY BEST TO KEEP A GOOD SCIENCE NOTEBOOK IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
PLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	UNPLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

ALL OF THE FOLLOWING STATEMENTS ARE RELATED TO YOUR SCIENCE COURSE THIS SCHOOL YEAR.

5. MY READING A SCIENCE RELATED MAGAZINE ARTICLE AT LEAST ONCE A MONTH IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
NICE	extremely	quite	slightly	undecided	slightly	quite	extremely	AWFUL

6. MY ASKING THE SCIENCE TEACHER QUESTIONS ABOUT SCIENCE IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

7. MY TRYING TO FIND OUT MORE ABOUT SCIENCE THAN WHAT WE LEARN IN CLASS IS

BORING	extremely	quite	slightly	undecided	slightly	quite	extremely	INTERESTING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
NICE	extremely	quite	slightly	undecided	slightly	quite	extremely	AWFUL

8. MY TRYING MY BEST TO SOLVE SCIENCE PROBLEMS WE ARE GIVEN IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
PLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	UNPLEASANT
NICE	extremely	quite	slightly	undecided	slightly	quite	extremely	AWFUL

ALL OF THE FOLLOWING STATEMENTS ARE RELATED TO YOUR SCIENCE COURSE THIS SCHOOL YEAR.

9. MY TAKING SCIENCE AS A SCHOOL SUBJECT IS

BORING	extremely	quite	slightly	undecided	slightly	quite	extremely	INTERESTING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

10. MY TRYING MY BEST TO GET A GOOD SCIENCE MARK IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

11. MY LISTENING CLOSELY TO THE TEACHER TALKING ABOUT SCIENCE IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

12. MY TRYING TO DO SCIENCE ASSIGNMENTS TO THE BEST OF MY ABILITY IS

BORING	extremely	quite	slightly	undecided	slightly	quite	extremely	INTERESTING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
NICE	extremely	quite	slightly	undecided	slightly	quite	extremely	AWFUL

ALL OF THE FOLLOWING STATEMENTS ARE RELATED TO YOUR SCIENCE COURSE THIS SCHOOL YEAR.

13. MY TRYING TO APPLY THE SCIENCE WE LEARN OUTSIDE OF CLASS IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
PLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	UNPLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

14. MY TAKING UP OF MOST OF THE SCIENCE TOPICS IS

BORING	extremely	quite	slightly	undecided	slightly	quite	extremely	INTERESTING
PLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	UNPLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

15. MY TRYING TO DO SCIENCE EXPERIMENTS OUTSIDE OF CLASS IS

INTERESTING	extremely	quite	slightly	undecided	slightly	quite	extremely	BORING
UNPLEASANT	extremely	quite	slightly	undecided	slightly	quite	extremely	PLEASANT
AWFUL	extremely	quite	slightly	undecided	slightly	quite	extremely	NICE

16. From the following list of grade 10 subjects, could you please rate the classes from most to least liked. The most liked subject is written by you into space #1, the second most liked into space #2 . . . and the least liked goes into space #5.

Grade 10 Subjects	Your Rating
1. English	1.__________ most liked
2. Math	2.__________
3. Science	3.__________
4. Social Studies	4.__________
5. Physical Ed.	5.__________ least liked

THANK YOU FOR YOUR ASSISTANCE AND COOPERATION!

SCORING THE ATTITUDE TOWARD THE SUBJECT SCIENCE SCALE (ATSSS)

The ATSSS was designed to measure student attitudes toward specific behaviors or activities which were typical in the learning of science at the junior high school level. An individuals' attitude toward each of the activities can be determined by summing the student responses for each of the 3 scales for each activity. For example, for the first activity, doing the science labs, there are 3 scales which ask for the student's attitude toward performing that activity (BORING-INTERESTING, PLEASANT-UNPLEASANT, and NICE-AWFUL). Each of these scales is given a score from 1-7. An X placed in the extremely space , next to INTERESTING ,PLEASANT, and NICE would be scored as 7. Conversely, an X placed in the extremely space next to BORING ,UNPLEASANT , and AWFUL would be scored as 1. An X in the spaces between these extremes is scored according to the number of spaces they are away from the ends. An X in the UNDECIDED space is scored as a 4. Missing data is also scored as a 4. The students attitude toward performing any of the 15 activities in the ATSSS is determined by summing the 3 scale scores together. Scores can range from 3-21. Roughly the meaning of these scores can be translated as follows:

3.0 to 5.6 (extremely negative) ; 5.6 to 8.2 (quite negative) ;
8.2 to 10.7(slightly negative) ; 10.7 to 13.3 (undecided or a mixed review)
13.3 to 15.8 (slightly positive) ;15.8 to 18.4 (quite positive) ;
and 18.6 to 21.0 (extremely positive).

What may be more useful is to rank order the mean scores for each of the activities from highest class mean to lowest class mean. This ranking will give the relative favorableness for each of the activities. The higher the mean score,the more favorable are the student attitudes' toward the actívity .

It is also possible to get an overall individual or class attitude toward the subject science by totalling the scores for all of the activities together. Scores can range form 45-315 Roughly , the total scores would mean the following:
45-85 (extremely negative) ; 85-125 (quite negative) ;
125-165 (slightly negative) ; 165-205 (undecided or mixed reaction)
205-245 (slightly positive) ; 245-285 (quite positive) ; and
285-315 (extremely positive).

The ATSSS can be used to assess class attitudes' toward activities related to the learning of science; individual student attitudes' toward the subject science; or to measure changes of student attitude toward specific activities during the course of the school year. Moreover, on question 16. students are asked to compare their science class to others they take. This comparison gives teachers some general feedback as to how students view the class.

In general, use of the ATSSS can give some information to the classroom science teacher on both what their student attitudes' toward the subject are and an indication of what factors in their class are important in terms of why the class is viewed negatively or positively. This information may help the teacher alter slightly some of their methods in order to promote even more positive attitudes toward the subject science.

NATURE OF SCIENCE QUIZ

Agree of disagree with the following statements about science.

Be prepared to defend your answer.

- A scientist must be imaginative in developing ideas which explain natural events.
- The value of science lies in its theoretical products.
- I do not want to be a scientist because it takes too much education.
- There is no need for the public to understand science in order for scientific progress to occur.
- When a scientist is shown enough evidence that one of his ideas is a poor one, he should change his idea.
- All one has to do to learn to work in a scientific manner is to study the writings of great scientists.
- I would enjoy working with other scientists in an effort to solve scientific problems.
- Scientific laws cannot be changed.
- Scientists believe that nothing is known to be true with absolute certainty.
- Scientific laws have been proven beyond all possible doubt.
- I would like to work in a scientific field.
- A new theory may be accepted when it can be shown to explain things as well as another theory.
- Scientists do not have enough time for their families or for fun.
- Scientists have to study too much and I would not want to be one for this reason.
- Working in a laboratory would be an interesting way to earn a living.
- I would enjoy studying science and using this knowledge in some scientific field.
- Once they have developed a good theory, scientists must stick together to prevent others from saying it is wrong.
- If one scientist says a theory is true, all other scientists will believe him.
- We can always get answers to our questions by asking a scientist.
- There are some things which are known by science to be absolutely true.
- Most people are not able to understand the work of science.
- Scientists cannot always find the answers to their questions.
- A scientific theory is no better than the objective observations upon which it is based.

- Scientists believe that they can find explanations for what they observe by looking at natural phenomena.
- Scientific work would be too hard for me.
- Scientists discover laws which tell us exactly what is going on in nature.
- Scientific ideas may be said to undergo a process of evolution in their development.
- The value of science lies in its usefulness in solving practical problems.
- When one asks questions in science, he gets information by observing natural phenomena.
- Public understanding of science is necessary because scientific research requires financial support through the government.
- Scientists do not need public support, they can get along quite well without it.
- Ideas are one of the more important products of science.
- Before one can do anything in science, he must study the writings of the great scientists.
- People need to understand the nature of science because it has such a great affect upon their lives.
- A major purpose of science is to produce new drugs and save lives.
- One of the most important jobs of a scientist is to report exactly what his senses tell him.
- If a scientist cannot answer a question, all he has to do is to ask another scientist.
- An important purpose of science is to help man to live longer.
- Science is devoted to describing how things happen.
- Every citizen should understand science because we are living in an age of science.
- I may not make many great discoveries, but working in science would still be interesting to me.
- A major purpose of science is to help man live more comfortably.
- Scientists should not circticize each other's work.
- His senses are one of the most important tools a scientist has.
- The products of scientific work are mainly useful to scientists, they are not useful to the average person.

Science Lesson Evaluation

The purpose of this form is to gather some information about how satisfied (how much you enjoyed) some of the science lessons this year. Please answer the following questions in order to help your teacher plan lessons that students find reasonably enjoyable. The answers to these questions are not for any marks and your names are not to be put on this form.

Directions: Put an X in the space above the phrase which best describes how you feel.

1) Relative to other science lessons we have had this year, how would you rate todays lesson:

Very Enjoyable	Enjoyable	Undecided	Unenjoyable	Very Unenjoyable

2) Rate todays lesson on the scale below:

Very Good	Good	Undecided	Poor	Very Poor

3) What did you enjoy/not enjoy about todays science lesson?