STUDENT ATTRIBUTE-PREFERENCE RELATIONSHIPS IN HIGH AND LOW CONTROL ELEMENTARY SCIENCE CLASSES

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ABSTRACT

This study was concerned with variations in teacher controlling behaviours within the context of elementary science classes, and the influence of student characteristics on affective outcomes under different control conditions. It was designed to determine which type of control was generally preferred, and to investigate relationships between student characteristics and their expressed preferences. In theory, student satisfaction is greater when a good fit between student attributes and learning environment can be maintained.

Two experimental treatments were defined from the teacher control continuum using the Bellack Observation System. Four teachers were trained to operationalize these treatments with 360 sixth grade elementary science students, in ten intact classes for two nine week rounds in the eighteen week study. A repeated measures design was used in which all classes were exposed to both treatments. An instrument was designed to measure student preference for the teacher behaviours characterizing the treatments. The design permitted a comparison of pupil attribute preference relationships across treatments within a sample for consistency, and across samples within a treatment for stability. An independent, task-oriented instrument was designed and administered to compare with the written instrument.

A large pool of independent variables was available to the researcher, so a data reduction procedure was

followed. Crossbreak analysis was used to identify potential predictors for multiple linear regression analyses. The nominal task-oriented data was analyzed by a crossbreak procedure.

The data collected indicated that the teacher behaviours were consistent with the definitions, but larger than desired inter-teaching variability within a treatment existed. The variables selected formed a significant set of predictors for student preference in all but one of the rounds of low control treatment. However, when the criterion of stability of findings across samples was invoked, none of the selected variables or subsets of variables significantly predicted student preference after teacher variation and other variable effects were controlled for.

A strong general preference for learning in the low control mode was expressed by students in both rounds, on both the written and task-oriented preference instruments. For the latter instrument, dominance, sex, and teacher effects survived the criterion of stability across samples, with submissives and girls choosing the unstructured task more frequently than dominant students or boys. However, this instrument and the written SPI preference instrument were observed to be essentially independent as determined by the Chi-square test. Zero order correlations of student attribute measures and SPI scores were calculated as a check on stability and consistency of the relationships

between these attributes and expressed preference. It was concluded that the observed relationships were stable and consistent on the basis of this analysis.

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I INTRODUCTION

1.0 Background for the study

The widespread use of classroom observation systems in the analysis of the educational process has substantially influenced the theoretical orientations of educational researchers in recent years. There has grown an increasing concern for the components of teaching, and the effects of these components in the educational process. Research centered around single components, or clusters of components, made possible by the multiplicity of observation systems currently available, now supplements more globally oriented research. Proponents of the new movement hope that the increased control afforded by observation techniques will eventually allow researchers to piece together a more accurate picture of the teaching process.

Grannis (1973) pointed out that the structuring of controls of the aims and conditions of education is of central concern in teaching. He suggested that a powerful approach to the study of teaching environments would be the examination of different distributions of controls over the various elements of the environment, and the consequences of these distributions. The validity of this approach is supported by the work of Soar (1973) on classrooms in Project Follow Through. His factor analytic studies of data derived from his observation schedules indicate that the more than twenty-five programs in the study could be most significantly discriminated along the dimension of control distribution.

Many early researchers focussed their attention on what was frequently described as teacher centered versus learner centered instruction. The now classic study by Lewin, Lippitt, and White (1939) on authoritarian, democratic, and laissez-faire leadership styles provided the impetus for many of these studies. Anderson's (1939) work on dominative and integrative behaviours, and Withall's (1949) articulation of the social emotional climate concept were noteworthy efforts in the early study of aspects of the control distributions in classrooms.

More recent research has been influenced by the work of Flanders (1970) and his associates. Working with an observation system, the Flanders Interaction Analysis Categories System (FIAC), Flanders has empahsized the ratio of indirect to direct teacher influence. A large body of research has grown around the Flander's conception of teacher influence.

In a review of research on control in classrooms, Morrison (1975) differentiates among several aspects of teacher leadership behaviour that have been confounded in the work of many researchers. The main confounding has been with the dimensions of leader restrictiveness or permissiveness and leader responsiveness or warmth. Morrison offers three dimensions of leader behaviour which he claims are distinct and may be incorporated under the concept of control. These are: (1) the way in which the teacher responds to deviant behaviour (2) the characteristics of the teacher's emotional relationship with the

class, and (3) the way in which the teacher structures the classroom, i.e. the extent to which the teacher imposes limits on the freedom of movement or freedom of choice of children in the classroom. He believes that the term control is most aptly applied to the third dimension specified, and cautions that understandings of classroom interactions will remain obscure if all of these dimensions are encompassed by this term.

The central concern with the concept of classroom control distributions is not limited to researchers using category systems to observe teaching. A commitment (Dunkin and Biddle, 1974) of progressive education to discovery learning gained impetus in the 1960's with the writings of psychologists like Bruner (1966), curriculum theorists and writers such as Taba (1963) and experienced teachers (Hendrix, 1961). This commitment has made a major impact on the development of the many new curricula in mathematics, physical and biological sciences which have come to us from this era.

Many of the new science programs stress a more unstructured kind of classroom setting, with pupils involved in small group investigations rather than the traditionally structured lecture/demonstration approach. However, within this activity oriented context, each program, both by its design and in its directives to teachers, seems to espouse different teacher control patterns, (Kuslan and Stone, 1972). Furthermore, it is reasonable to assume that within the constraints of

any particular program, teachers will vary in the amount of control they choose to exert over both small group and large group interactions. The Science a Process Approach (SAPA) program for example, with its relatively structured nature, requires that the teacher exert more control in terms of pacing, direction giving, etc. than programs like the Elementary Science Study (ESS). SAPA or ESS teachers are individuals, however, and it seems reasonable to expect variance in the amount of control teachers within the same program will display.

The concept of teacher control, then, emerges as a significant and important variable from the general body of research on teaching literature. As well, it is a central concern for those wishing to evaluate some of the contemporary approaches to elementary science teaching. These new programs, and the patterns of control they espouse, have led to a great body of research relating to the advantages of one pattern over another. Reviews of the literature (Shulman and Keislar, 1966; Hermann, 1969) on discovery learning for example, provide few firm conclusions from the research, however. Rosenshine (1970) and Dunkin and Biddle (1974) found a similar state of affairs for observational research.

Part of the problem is that the diversity of approaches used by researchers makes comparisons of findings extremely tenuous. As the data relevant to aspects of teacher control distributions accumulated and the number of insignificant differences mounted, researchers began to

pay more attention to writers like Cronbach and Snow (1968) and Hunt (1971, 1975) who have articulately argued that the inconclusiveness of much research is in part due to the failure to use an Aptitude-Treatment-Interaction (ATI) approach. The heart of such arguments is the belief that averaging the scores of groups of subjects on various criterion measures conceals individual variability, and that it is possible to identify characteristics of the subjects which predispose them to perform better on a criterion under one treatment than another. Instead of the search for significant differences between the mean scores of different treatment groups on outcomes of interest, the ATI approach involves the following rationale: (Cronbach and Snow, 1968, p6):

> "Assume that a certain set of outcomes from an educational program is desired. Consider any particular instructional treatment. In what manner do the characteristics of the learners affect the extent to which they attain the outcomes from each of the treatments that might be considered? Or, considering a particular learner, which treatment is best for him?"

The notion of interaction between student characteristics and teaching method is particularly appealing at a time when educators are attempting to "pay more lip service to the view that students are all different and should be taught as individuals", (Stanton, 1974, p.481). However, the ATI model has not been as fruitful as its proponents expected. The inadequacy of theory to guide the selection of student characteristics which might be expected to differentially affect student outcomes under

experimental treatments has left researchers no alternatives in many instances but to make the selection a priori, or conduct multivariate, exploratory studies. (Goldberg, 1972).

The selection of student characteristic variables likely to interact with experimental treatments differentiated in terms of patterns of control in the classroom must be undertaken with reference to the criterion variable chosen for investigation. A remarkable proportion of the studies on teaching styles have emphasized student achievement as the criterion. This criterion is perhaps the simplest to measure objectively, and for some, the most important criterion for study. However, one is struck by the equally remarkable inconsistency, and insignificance of findings on this criterion. Shulman and Tamir (1973) point out that we are entering an age in education where the feelings of the student are recognized as "necessary adjuncts" to the cognitive learning and as "coequal consequences" of instructional approaches. Brophy and Good (1974) caution that many students see school as a negative experience to be endured, and many consequently drop out of school. Mager (1968) has said that the likelihood of the student using his knowledge is influenced by his attitude for or against a subject. People tend to avoid those things they feel unfavourably about, except when circumstances prevent them from doing so. Mager puts the point strongly by arguing that positive feelings towards activities we teach might well be our "minimum and universal goal" in teaching (p10).

Getzels (1968) argues that the aim of the school is to

maximize behaviour that is educationally "effectant". Effectance is a term used to describe the relation between the effectiveness and efficiency of the educational setting, viewed as a social system. Effectiveness refers to the success of the system in achieving its goals, and efficiency refers to the degree of satisfaction experienced by members of the system in their attempts to meet the goals of the system. Behaviour is termed effectant when it is simultaneously efficient and effective; and it is not effectant to the degree that there is a discrepancy between its effectiveness and efficiency.

Getzels points out that individual efficiency will depend upon the match of role expectations established by the school on the one hand, and the personality dispositions of the child on the other. The child's behaviour will correspond to one or the other, or some intermediate compromise. To the extent that behaviour can correspond to the latter within the parameters of the school setting, it is efficient.

Different patterns of control in the classroom establish different role expectations for the students. Children's personality dispositions, couched in the diverse values available to them for internalization, will lead to various degrees of individual efficiency. Understanding the relations between childrens' characteristics and the efficiency of their behaviours under various patterns of control is an important research goal, which has implications for nearly all facets of the educational process.

1.1 The problem

The problem, then, is not simply which type of classroom setting is best, but rather which setting is best for a particular kind of student. In this study, the investigator was interested in singling out teacher control as a component of the classroom setting worthy of further study. It seemed reasonable to hypothesize that variance along this dimension should affect pupils both cognitively and affectively; however, the investigator was primarily interested in affective outcomes and the influence of pupil characteristics on these outcomes under the different conditions of teacher control.

Is there a general preference for one kind of teacher control over another? What kind of student prefers to be subjected to a high degree of teacher control, and what kind of student would prefer a less restricted learning environment? Pervin (1968) argues that individuals will be positively attracted towards objects in the environment that hold promise for taking them toward their "ideal selves" and are negatively disposed toward objects that hold promise for taking them away from their ideal selves. A good fit of environment to the characteristics of a student should therefore lend to satisfaction, whereas lack of fit should lead to dissatisfaction as expressed by preference for an alternative kind of environment.

This study was part of a larger study involving other researchers. The main project was concerned with the

influence on pupil behaviour of different degrees of teacher control, and the interactive effects of teacher control with pupil characteristics. High and low control treatment conditions were defined in terms of a category system developed by Crocker, et. al. (1975). This system developed for analyzing interaction patterns in elementary school science classes, and sought to overcome the limitations of some of the more widely used classroom observation systems (Bales, 1950; Bellack, 1966; Flanders, 1970) for such a special context. It was hoped that this procedure would give a clear definition of the experimental conditions, and provide a means of verifying actual implementation of the treatments, since video-taped samples of classroom interaction could be anaylzed for this purpose.

Although the variation in teacher control as defined in this study was unique, several researchers have varied classroom environments in a fairly comparable fashion. A review of the literature revealed several potentially fruitful variables for inclusion in the study. It was decided to make the study as broad as was practical, since no particularly strong theoretical or empirical basis existed for the selection of variables. In some cases then, variables were selected on an a priori basis, because the investigator was interested in their possible effects. In others, variables from related studies were chosen. Finally, some variables were included because they were readily available

as part of the data pool related to the larger study. A refinement procedure was included in the data analysis, since it was anticipated that many of these variables would have high intercorrelations.

Specifically, the student characteristics included in the study were:

1. sex
2. socioeconomic status
3. self concept of academic ability
4. past experience in science
5. dependency
6. dominance
7. extraversion
8. neuroticism
9. locus of control
10. pupil ability
11. attitude toward school
12. attitude toward science

1.2 Significance of the study

The attractive possibility of matching teaching style to predominant student orientation to increase teaching effectiveness and efficiency will become more realistic only as a larger pool of experimental results relating student characteristics and carefully defined teaching styles for desirable outcomes becomes available for analysis. With the relatively broad range of student characteristics included in the study, and the regression technique used to assess their effects on the attitude criterion, it is hoped to contribute significantly to this pool.

The evaluative significance for the current activity based elementary science programs must be considered in the light of the approach adopted in this study. It was hoped to speak to such issues as which curriculum approach is preferred

by which kind of student, not simply which is more preferred. In this sense the information derived from this study could be used to contribute to the greater effectance (Getzels, 1968) in the educational activity.

The study is not to be confused with the myriad of studies on discovery learning. Students in both treatment groups in the study were involved in activity oriented, process-based science lessons. Treatments were differentiated in terms of the way in which the teacher structured the classroom or exerted control over classroom events. However, in the sense that discovery learning approaches tend to espouse some of the elements of the low teacher control strategy, the studies are somewhat related. By the same argument; lecture approaches may tend to display some of the high control teacher behaviours.

Several studies have focussed on student preferences for teaching style with college level subjects, but few have emphasized this criterion at the elementary school level. As pointed out by Brophy and Good (1974), the generalization across such a large context difference is rarely justified.

Several studies have employed measures of student attitudes toward science, schools, and teachers under treatments differing by degree of teacher structuring of tasks, ordering of rules and examples, etc. However, no studies have explicitly measured elementary science students' preferences for teacher control in an activity based curriculum.

Many researchers who have attempted to measure on affective criteria in the context of treatments somewhat similar to this study have been plagued with confoundings of such variables as teacher warmth, teacher response to deviant behaviours, degree of activity of learning, number of examples, amount learned, and so on. In this study, the explicit nature of the criterion instruments, mode of analysis, and counterbalanced nature of the experimental design, will reduce the chances of findings being subject to such confoundings.

The short term nature of most of the reported studies relevant to the present study casts serious doubts upon the external validity of their affective outcome measures. Although the investigator realizes the concomitant control problems, it is concurred with Worthen (1968) that classroom experiments where time and content are representative of typical school behaviour and curriculum can be generalized to classroom practice more confidently than could the results of the typical short term experiment. The children involved in the study must experience the treatments long enough, and in a natural enough setting to remove the well known halo effect which can so seriously jeopardize affective assessments.

In summary, the investigator believes that the context, treatments, criterion measures, approach, and design of this study will allow it to make a worthy contribution to the study of teaching.

II RELATED RESEARCH

2.0 Teacher control perspectives

A large number of studies have differentiated experimental teaching strategies on the general dimension of control or degree of structure. Comparisons of the research results, however, is very difficult, because of the wide variety of approaches used to operationalize teaching styles within this general framework.

The major problem, according to Morrison (1975), is that the concept of control as it is presently conceived has too many "overtones" and "connotations", (p39). Kounin's (1970) work, for example, illustrates the classroom management aspects of the control dimension. Such teacher variables as "with-it-ness" (the degree to which a teacher could correctly distinguish between significant and insignificant child misbehaviour) and "smoothness" (the manner in which the teacher manages movement during recitation and transition periods), were identified as significant aspects of teacher behaviour that relate to managerial success in the classroom. Kounin's criteria for this assessment were "work involvement" and "deviancy", while "recitation" and "seatwork" were the learning settings chosen as representative of school activities.

The increased emphasis on observational studies of classroom interactions has led to operational definitions of teaching styles related generally to the topic of classroom control. One of the most widely used systems, the Flanders Interaction Analysis Category System (FIAC), generated a

large body of research related to what Flanders (1970) called "direct" and "indirect" teacher influence. "Indirectness", as perceived by Flanders, is indicated by the extent to which a teacher "accepts feelings", "praises or encourages", "accepts or uses students' ideas", and "asks questions". Directness, on the other hand, is a measure of a teacher's tendency to "lecture", "give directions", or "criticize", or "justify authority". The categories of FIAC used to calculate these measures have been criticized by Morrison (1975) as reflecting components along two distinct dimensions: control, on the one hand, and emotional resposiveness, or teacher warmth, on the other. He cites evidence from several factor analytic studies to support the claim that teacher control and teacher warmth are distinct dimensions. Dunkin and Biddle (1974), in an exhaustive review of studies on teaching, concluded that the majority of studies which investigated the effects of teacher directiveness and teacher warmth indicated that these concepts seem to operate independently.

Another perspective on classroom control is that exemplified by O'Leary, et. al. (1971). Rooted in animal experimental psychology, these classroom modification studies view control as a matter of teacher provision of reinforcements after the appearance of pupil behaviours that are to be encouraged or discouraged.

Thus, many inquiries into the relative advantages of one teaching method over another can be identified with one or

more of these three major research traditions related to classroom management and control:

1. classroom management and discipline
2. teacher directness
3. reinforcement and behaviour modification

Discovery learning research (Hermann, 1969) is related to research on the teacher directiveness dimension, for example. Shulman and Tamir (1973) point out that the most "intuitively meaningful conception of discovery learning is teaching that is minimally guided or directed by the teacher". This form of instruction is usually contrasted with more directive forms called "traditional", "expository", "guided", "didactic", "teacher-centered", or "dogmatic". The labels applied to experimental treatments in current research indicates the research community's continued preoccupation with the dimension of teacher guidance. "Expository", "laboratory", and "discovery" groups were investigated by Babikian (1971); "Teacher structured" and "student structured" conditions were used by Shymansky, et.al. (1974); whereas Stanton (1974) studied the effects of "lecture" and "independent study" methods.

It can be seen that numerous variables presently in use in educational research can be loosely related to the topic of classroom control, but lack of consensus on variable definition makes comparison of experimental outcomes practically impossible.

Social systems theory (Miller and Rice, 1967; Rice, 1965) offers some theoretical assistance in clarification of the

control concept. Control is referred to as the leader's regulation of transactions across what are termed "boundaries" of the system. Boundaries are discontinuities in space, time, or behaviour for which controlled transitions exist. The teacher, as leader in the classroom social system, has to control transactions so that learning is accomplished with maximum effectance (Getzels, 1968). A high control classroom, then, is one in which the teacher carefully regulates transactions among students. In these classrooms the students use of time and space, and the kinds of interactions they can have with other members of the class, are subject to teacher imposed constraints. In low boundary control classrooms, on the other hand, students would be freer to initiate and regulate their activities. "Permissive" or "non-directive" labels could well be applied to teachers who kept low control over classroom boundaries, whereas "authoritarian" or "directive" teachers would display high boundary control To the extent that individuals have personal needs which must be satisfied within the context of interpersonal relationships, boundary control decisions that regulate the interaction of the student and his environment will mediate the satisfaction that can be derived from the classroom system.

2.1 The Bellack system

To operationalize the concept of control and to establish treatments which could clearly be identified on the control dimension, the researchers involved in the project which

contained this study turned to the efforts of Bellack and his associates (1966). The classroom observation system developed by Bellack et. al. reflected the theoretical consideration of classroom activities as a game, with well understood rules governing what are termed "moves". These moves are units of verbal interaction, and consist of one or more sentences uttered by a speaker that have a discrete intent or contain a common content. Moves are grouped into four basic categories, classified according to their function in the classroom language game. These structuring, soliciting, responding, and reacting moves can each be coded according to their substantive and instructional content. The structuring moves serve to set the context of subsequent behaviour, while soliciting moves are designed to elicit verbal or physical behaviour. Responding moves follow soliciting moves, and fulfil the expectations created by the soliciting moves. Reacting moves modify or rate prior moves. Substantive content of moves refers to the subject matter under discussion, whereas instructional content, of particular interest to this study, applies to factors related to classroom management.

The Bellack system was modified by Crocker, et. al. (1975) to serve the specific function of observing classroom settings where small group work was the characterizing feature, as was the case in the present study. Low and high control teaching strategies were defined operationally in terms of the modified observation

system. The distinctions were made on the basis of the pedagogical move distributions, as well as instructional content differences in the moves, as outlined later in this study.

2.2 Affective outcome perspectives

Predominantly, attempts to measure affective outcomes of different instructional strategies in the context of science lessons have been concerned with "attitudes toward science". Several studies have been concerned with other categories of attitudes such as "attitudes toward scientists", and "scientific attitudes". In more general contexts, researchers have measured attitudes towards treatment teachers, and satisfaction or interest experienced in the various treatments. Studies which have employed test batteries to collect measures on several of these variables (Gardner, 1975; Soh, 1972) report these categories of attitudes are often interrelated. Writings such as those by Stern (1970) and Kelman (1966) suggest that attitudes are not simply isolated characteristics of an individual, but form patterns which are linked to the individuals' personality structures. We could therefore anticipate relationships between students' attitudes and aspects of personality. Weichmann and Weichmann (1973), in an extensive exploration of theoretical positions on attitudes, distinguished three perspectives for considering the construct: as a latent variable, an attitude may be said to exist following perception and prior to reaction toward an attitude object; as an intervening variable, an

attitude is viewed as mediating knowledge and behaviour; and as an inferred variable, attitudes apparently underlie psychological or physical reactions.

In the present study, the investigator was concerned with students' specific attitudes toward controlling behaviours, and the learning settings created by these behaviours. It was reasoned that if students perceived defined controlling behaviours, attitudes would be formed which would determine their reactions to these behaviours. Variables such as ability, personality, social class, experience, etc., would be likely predictors of these reactions. The usual categories of attitudes, such as attitudes toward science, or pupil interest, would be loosely related measures, particularly if they were measured in contexts similar to those of this study.

2.3 Studies of teaching style and affective outcomes

Johnson, et. al. (1974), in a study of 108 sixth grade elementary science students using materials similar in nature to this study, reported that significantly more positive "attitudes towards science" resulted for students interacting with concrete materials than for those studying similar material from a textbook. However, the amount of activity could have been the source of variation in attitude scores.

Rian (1969), using the FIAC system in a study of teacher indirectness with grade seven history students found that pupil satisfaction was not significantly related to this variable. However, Dunkin and Biddle (1974), in an

exhaustive review of studies on teacher indirectness, found eight studies supporting the hypothesis that more positive pupil attitudes were associated with teacher indirectness, and three studies which did not support this hypothesis. Gunnison (1968) reported that grade nine social studies students showed that "indirectness" was significantly related to positive student attitudes towards teachers.

Stallings and Kaskowitz (1974) reported that grades one and three students were absent less frequently in classrooms characterized as "open" classrooms, with a high degree of child independence, questioning, adult responding, individualized instruction and open-ended questioning. The inference here is that students had more positive attitudes toward the open instructional setting.

Soar (1973) has reported that first graders are generally happier and like school best when it is well structured and firmly in the teacher's control. There is some evidence, however, (Wallen and Wodtke, 1963) that childrens attitudes toward teaching style change with age, with a shift toward " warm " and more " permissive " teachers occurring around the second or third grade.

In a review of studies using the FIAC system, Flanders (1970) has concluded (p. 401) "when pupils have opportunities to express their ideas, and when these ideas are incorporated into the learning activities, then the pupils seem to develop more positive attitudes toward the teacher and the learning activities." Most of the studies

reviewed were field studies rather than experimental designs. Flanders, following Soar (1968) has advanced the notion that there could well be a curvilinear relationship between teacher indirectness and pupil attitudes in the sense that an optimum degree of teacher indirectness exists in a particular context beyond which attitude scores may decline.

There is then, a substantial amount of evidence to suggest that students have more positive attitudes toward the low controlling, permissive, or indirect teaching style. However, there are confoundings with level of activity which make these findings tenuous. Many of the studies which have contributed to the conclusion of positive correlation between "indirectness" and positive attitudes were field studies which made no attempt to measure the amount of activity in the groups they identified as "direct" and "indirect". In the present experimental study, both treatment groups will be involved with the same activities and thus less subject to this confounding.

2.4 Student characteristics and affective outcomes in teaching style studies.

Several researchers have concerned themselves with the more detailed problem of identifying student characteristics which relate attitudes to instructional style.

Arlin (1975) investigated the relationship of academic locus of control on degree of pupil satisfaction in open and structured classroom settings. Using the locus of

control construct described by Crandall, Katkovsky and Crandall, (1965) Arlin found significant interactions of locus of control by "openness" by attitude, with "internal" students showing more positive attitudes toward "learning Processes" and teachers in the "open" setting.

A significant sex by locus of control by "openness" effect was also reported by Arlin, with male internals having more pronounced positive attitudes than girls in the open setting. Internal students displayed more positive attitudes toward both learning processes and teachers than did external students. These interactive and main effects are difficult to place in perspective, since Arlin's work was essentially a field study with teachers designated as "open" or "traditional" on the basis of the "Principal and Supervisor Rating Form" (Katz, 1972). It is impossible to tell how the groups differed in terms of the control dimension, or what confoundings of subject matter, teacher warmth, etc., existed. However, the large sample (fifteen "open" teachers, fifteen "traditional" teachers, 660 elementary school pupils) makes the research relatively respectable.

Babikian (1971) differentiated his teaching of science concepts treatments into "expository", "laboratory", and "discovery". The first method was entirely verbal, whereas the last two differed only in terms of instructions provided with the laboratory apparatus. Thus these last two treatments more closely approximate the treatments

used in the present study. Eighth grade science students were taught by Babikian in the three treatment groups. A four item opinionaire was administered at the end of each one week treatment. Girls rated the expository method significantly more interesting than the discovery method. In fact, the expository method was considered the "easiest", "clearest", and "best" method by the sample. The results of this research are suspect however, since only one researcher was used (the investigator) and subjects had to rate the treatments with respect to their regular classes, about which no information is given. A contradictory study by Anderson (1960) found that girls preferred instruction which was "indirect".

A student characteristic called "dependence proneness" was investigated by Flanders, et. al. (1961). A dependent prone student was defined in terms of a scale (The Dependence Proneness Scale) devised for the study, and is described as one who is compliant, having a high need for teacher feedback and supervision. A student who scored low on the scale prefers to be left alone with the given task and has less need for teacher approval. Anderson, in the study already cited, found that students identified as high dependent prone on this scale preferred a less directive teacher than low scoring students on this scale. Wispé (1951) and Covington (1972) in studies involving college students, found that students classified as dependent, insecure, or conforming preferred more directive or structured learning situations.

Crocker, et. al. (1976), in a study similar in design to the present investigation, tested the effects of sex, intelligence, creativity, socioeconomic status, and personality variables on student achievement and preferences in what was described as "structured" and "unstructured" teaching strategies. The results relevant to the present study showed that there was a significant preference expressed for the structured strategy. However, the only characteristic which significantly interacted with the treatment and preference was intelligence, with high IQ students expressing a stronger preference for the unstructured strategy than the low IQ students. The personality variables included in the study were neuroticism, dependency, and extraversion. The small sample size (120) and difficulties experienced in the construction of the preference instrument make the results difficult to assess.

With older subjects, research on the relationships of student characteristics and attitudes have been conducted by Stanton (1974), Tuckman (1968), Tuckman and Orefice (1973), McKeachie (1958), and Pascal (1971), in addition to those by Covington and Wispé already cited.

In Stanton's study, 106 university students covered the first half of an educational psychology course by the traditional lecture method, and the second half by independent study. Personality data on the subjects was obtained using the Eysenck Personality Inventory (EPI), Eysenck and Eysenck (1964); Cattell's Sixteen Personality

Factor Inventory, Cattell (1962); and the Face Valid Scale (FVS), Allport (1960). Preference information was gathered at the beginning and at the end of the course. It was found that neuroticism, as measured by the EPI, was significantly related to student preference, with the more anxious student preferring to attend lectures. None of the other personality measures on the EPI or 16PF were significantly related to preference. The FVS instrument indicated that students who chose to attend lectures rather than to work independently could be characterized as less concientious and persevering, more practical, conventional and careful, and less self-sufficient and resourceful. Preference information taken at the end of the course showed essentially no change from the beginning, suggesting that the choice was stable. McKeachie's findings seem to support these, in that students in his study who expressed a preference for structure tended to be personally insecure and feared failure.

Tuckman (1968) studied eleventh and twelfth grade students in a vocational education setting. Using the Interpersonal Topical Inventory, ITI (Tuckman, 1966), to collect the personality data, and an instrument called the Student Perception of Teaching Style to distinguish 12 directive and 12 non-directive teachers, Tuckman reported a significant preference was expressed for the non-directive teachers. Preference for the teacher was measured by a rank ordering procedure. Satisfaction was measured and found to be higher with the non-directive teachers.

Students characterized as "abstract" and "non-authoritarian" by the ITI scales showed more preference and indicated more satisfaction with the less directive teachers than with directive teachers. No significant differences on these affective measures were found for the "concrete", "dependent" students. Tuckman and Orefice (1973) in a similar study, found that "abstract" students preferred self-study over three more structured forms of learning. As in the previous study, "abstract" referred to tendency to be open-minded, flexible, and multidimensional, whereas "concrete" referred to a tendency to be close-minded, rigid and overgeneralizing. Students experienced only one type of treatment, and their relative expressed liking was taken as a preference measure. An interesting variable called study time showed that concrete students spent the least study time on the instructional method they liked least, so the authors deemed study time to be a preference measure. However, it is by no means clear from the study that concrete students preferred structured approaches to learning since their highest mean preference, like the abstract students, was for the self study method. Also, it was interesting to note that concrete students spent more study time in this approach than abstract students did.

In a different approach, Pascal (1971) recorded the preference of 185 college psychology students for treatments labelled independent study, lecture, and lecture-discussion. The students were randomly assigned to the treatments so that about half received their most preferred

method of instruction. Students who received their preferred treatment showed a significantly more positive attitude toward the course than those who did not.

2.5 Summary of related research

Attitude related studies have been conducted in a wide variety of field and experimental settings. Treatments involving the teacher control dimension have been operationalized from an equally broad variety of perspectives, with many studies confounding teacher warmth with teacher control, and others confounding level of activity with treatment. These problems are compounded by the many facets of the attitude construct. A clear definition of teacher control with a means to ensure that teacher behaviours actually are in agreement with treatments operationally related to these definitions would be a major improvement over most of the experimental studies reviewed. Attitude measures which relate directly to the treatments, rather than bearing no defensible connections, would also improve the state of research in the affective domain.

2.6 Teacher control and affective outcome perspectives of the present study

In this study treatments were differentiated on the basis of teacher controlling behaviours derived from a modified version of the Bellack observation system. All students were involved in an activity based curriculum. The investigator was primarily interested in students

affective responses to the components of control by which the treatments were varied. A review of currently available instruments revealed a variety of scales appropriate for measuring changes in attitudes toward science, attainment of scientific attitudes, or attitudes toward scientists: Moore and Sutman (1970), Klopfer (1969), Markle and Capie (1974), Ralph (1972).

However, none of these specifically addressed the issue of student feelings regarding specific teacher behaviours which determine their learning conditions. Consequently, it was necessary to construct an instrument specifically for this purpose. The source of items was the treatment definitions themselves. These definitions were interpreted for the purposes of training the teachers involved in the research project. It was felt, therefore, that these interpretations would be the most reasonable source of variance in teacher controlling behaviour, and hence the most logical starting points for scale construction. The instrument was constructed to yield a score which indicated a student's preference for the high or low controlling behaviours used to define the treatments, and could be interpreted as a measure of liking for the experimental treatments.

Many variables have emerged from the body of research on attitudes as potential predictors of pupil affect under conditions reasonably consistent with those of the present study.

The distinctness of effects reported is questionable,

however, since high intercorrelations often exist between pupil attribute variables. Personality, ability, and pupil background variables are often significantly correlated, for example, and it would appear to be reasonable to try to assess their relative importance in predicting pupil attitudes.

Fortunately, the present study had at its disposal a fairly representative sample of these various kinds of variables since it was part of a much larger study. Relationships among the variables could thus be explored, and the relative importance of variable relationships with the criterion of student preference could be tested.

Some variables then, were included in the study because of their availability, rather than their direct interest to the investigator. This somewhat exploratory approach was judged reasonable, since no particularly strong empirical or theoretical arguments for variable selection or rejection in attitude related research were found.

To make the study more manageable, specific hypotheses were stated only after the variable field had been narrowed by preliminary investigation. A description of the variables available to the study and the selection procedure used to focus the study on a particular subset of these variables is found in the following chapter.

III EXPERIMENTAL METHODS

3.0 Definition of experimental treatments

Teacher behaviours for the high and low control treatment groups were defined in terms of the modified Bellack observation system (Crocker, et. al. (1975))referred to earlier in this study. Teachers in the study were trained to teach in a manner displaying high or low values of these behaviour variables, but it was considered impractical to prescribe the specific range of values for each variable. To do so would require teacher adherence to a lesson script, which would make the treatment lessons quite unrepresentative of the natural classroom settings. Table 1 shows the variables used to distinguish the treatments with their projected relative values. To check if treatment teachers had indeed operationalized the treatments as planned, 13 randomly chosen sample lessons were videotaped and coded, providing approximately 130 minutes of lesson time from each treatment. The results of this monitoring procedure are presented later in this study (table 7).

3.1 Study sample

Eleven intact classes of sixth grade students from six schools within the Avalon Consolidated School District, St. John's, Newfoundland were originally obtained for the study. One of these classes was subsequently deleted from the main data analysis because the students were already familiar with some of the content used in the study. This class was used for assessing the reliability of several instruments employed during the project. Thus ten classes from five schools were retained as the operative sample.

Table 1

Variables used to differentiate experimental treatments

Variable		Relative Value	
		High Control	Low Control
1.	Amount of teacher-class interaction	High	Low
2.	Amount of teacher-group interaction	Low	High
3.	Proportion of pupil talk during teacher-class interaction	Low	High
4.	Proportion of pupil talk during teacher-small group interaction	Low	High
5.	Number of teacher structuring moves	High	Low
6.	Number of teacher soliciting moves	Low	High
7.	Number of teacher responding moves	Low	High
8.	Number of teacher reacting moves	High	Low
9.	Ratio of commands to total teacher solicits	High	Low
10.	Ratio of requests to total teacher solicits	Low	High
11.	Frequency of pupils reporting individual results	Low	High
12.	Teacher substantive-logical discourse	Low	High
13.	Pupil substantive-logical discourse	Low	High
14.	Average wait time	Short	Long

The sample schools are located in a region with a population of approximately 250,000 people, about half of which live in the city of St. John's. The remainder live in several smaller communities clustered within commuting distance of the city. Many of these communities have populations of less than 1,000 while the largest has about 5,000 people.

The main population area is primarily a government and university centre with several light industries. In the smaller communities, the work force is predominantly engaged in primary activity, although many people living in these areas commute to the city. Hence, a wide range of socio-economic classes exists throughout the region.

Three of the schools in the study could be classified as older, central city schools, and the remaining two as newer, suburban type schools. The newer schools had such features as open areas and large resource centres, but had slightly larger classes than the older schools. Class size ranged from 30 to 40 students. Students in the sample did not have a wide prior experience with science.

Table 2 displays some characteristics of the samples. The socioeconomic measure (SES) was determined from the Blishen (1967) scale, categorized by assigning cutting points at standard deviation units from the mean reported for Newfoundland. This gave four categories above the mean and two below. Highest SES was categorized as Unit 1, and lowest SES was categorized as unit 6.

Table 2

Sample characteristics of ten study classrooms

Class	1	2	3	4	5	6	7	8	9	10
Male	16	17	15	15	15	24	39	23	21	11
Female	20	19	20	18	20	16	—	16	16	19
Total	36	36	35	33	35	40	39	39	37	30
Age(yr)	11.3	11.1	11.2	11.4	11.4	11.2	11.1	11.3	11.3	11.4
Years of Science	1.2	1.4	1.3	2.5	1.8	4.2	3.9	3.4	1.7	1.2
SES	4.3	5.0	4.7	4.8	4.6	2.8	3.3	2.7	3.7	4.5
IQ	37	38	35	38	35	40	40	42	45	37

3.2 Curriculum context of the study

The science program used was adapted from Science A Process Approach (AAAS, 1968). The activities used focussed on the interpreting data and controlling variables processes, but since the pupils did not have the necessary background, a unit on measurement was included to ensure they had acquired the requisitequantifying skills.

Activities adapted for the program were designed to occupy one or two class sessions. Enough apparatus was provided so that students could work in groups of two. Typically, a lesson would begin with the introduction by the teacher, followed by a period in which pupils would set up their apparatus to make observations of some sort, and end with a discussion of the data gathered.

Three content units were taught during the study. The

first unit called "Batteries and Bulbs" dealt with variables influencing the brightness of flashlight bulbs in various types of circuits, and variables affecting the strength of electromagnets. The second unit, "Human Reactions", involved variables affecting pulse rate and learning/forgetting rates. The final unit, labelled "Mechanics", dealt with using a balance and investigating the factors affecting the stretching of rubber bands. Appendix F gives an objectives and activities cross reference chart for these units.

The objectives were grouped under the processes of quantifying, controlling variables, and interpreting data. Activities were designed to reach these objectives in each of the treatment groups. In each treatment group, students worked in pairs with apparatus. The level of activity and the time spent working with materials was essentially the same for high and low control classes, but teacher behaviours in the two situations were different.

As an example, one of the objectives under the controlling variables heading was the conduct of investigations with one manipulated and one responding variable, while holding other variables constant. In the "Batteries and Bulbs" unit, students investigated the brightness of bulbs as a function of the number of cells in the bulb circuit. The "Mechanics" and "Human Reactions" units presented investigations to aid in the attainment of this objective as well, with content material appropriate to the particular unit.

While students were involved in small group activity in their investigations in both treatment groups during all units of study, the type of teacher behaviour varied with the treatment. For example, the amount of direction giving during the initial apparatus set-up varied from high control to low control. A more complete outline of treatment differences was outlined in section 3.0.

3.3 Experimental design

Four experienced elementary school teachers were employed by the project. They were given a one week training period on the lesson content and treatment variations. An example of some instructions discussed with teachers is given in Appendix A. One of the teachers acted as a coordinator for the lesson preparation, handling of materials, and other related work, while the others were attached to the study on a part time basis. The project teachers replaced the regular grade six science teachers for the duration of the 18 week study. The reactive effect of using special teachers in the school was offset by the flexibility permitted the researchers. It was possible to assign teachers to classes in a balanced fashion, to aviod the problem of teacher personality effects which often are confounded with treatment effects.

A repeated measures design was used in which all classes were exposed to both treatments. This design was judged

appropriate because of the small number of classes in the sample. During the first nine weeks of the study, four classes were assigned to the low control treatment and six to high control. In the remaining nine weeks, each class was assigned to the alternative treatment, and teachers were reassigned. The assignment of teachers to classes and the sequence of treatments for classes was on a random basis, with the constraint that an attempt was made to assign each teacher to at least one class of each treatment for both rounds. Table 3 shows the design employed. Round one refers to the first nine weeks of the study, whereas round two refers to the second nine weeks when classes were reassigned. Criterion measures were taken at the end of each round for both high and low control groups.

The design permitted the investigator to determine treatment effects on student preference relatively free of confoundings by teacher and class. Within each round, confoundings by teacher and class did exist, but by treating the two rounds as replications with teachers assigned to different classes in each round, these problems were reduced.

The relationship of student characteristics to student preference within a treatment can be studied by treating the two high and two low control groups separately. Observations on the high control group in the second round may be compared with observations on the high control group of the first round. The same procedure could be used with the low control group. Only characteristics which are significant predictors of

Table 3

Experimental design

Round 1 (Weeks 1-9)				Round 2 (Weeks 9-18)			
High Control		Low Control		High Control		Low Control	
Teacher	Class	Teacher	Class	Teacher	Class	Teacher	Class
4	2	4	1	2	1	2	2
2	3	4	4	3	4	4	3
2	5	1	8	1	8	3	5
1	6	2	10	4	10	1	6
1	7					4	7
3	9					1	9

Note: Classes 6 and 8 were taught by the same teacher in both rounds

preference in both analyses would be considered significant results of the study. Another advantage of this breakdown is that comparisons of a sample's liking for high control may be compared to the same sample's liking for low control, and vice-versa. Consistency of results would indicate stability of relationships.

3.4 Data sources

The independent and dependent variables of interest in this study are summarized in Table 4. The instruments used to measure on these variables are also listed, together with reliability coefficients where appropriate. A discussion of these instruments follows.

Table 4

Summary of independent and dependent variables

Variable	Source	Reliability Coefficient	Reliability Method
Treatment (TREAT)	coded data from video/audio tapes	.50-.59	inter-rater agreement
Sex	school records	-	-
SES	Blishen Scale	-	-
Self Concept (SCONA)	Modified Brookover Scale	.72	test-retest
*Past experience in science (YEX) (TEX)	Pupil Questionnaire	-	-
Dependency Proneness (DPS)	Amidon & Flanders (1961) Dependency Proneness Scale	.68(original) .91(Elliot, 1973)	test-retest

Table 4 (continued)

Summary of independent and dependent variables

Variable	Source	Reliability Coefficient	Reliability Method
Submissive/ Dominance (SUBDOM)	Children's Personality Questionnaire	.74-.82	split-half & parallel forms
Extraversion (EXTRA)	Junior Eysenck Personality Inventory	.70-.80	split-half & test-retest
Neuroticism (NEURO)	Junior Eysenck Personality Inventory	.70-.80	split-half & test-retest
Locus of control (IAR)	Intellectual Achievement Responsibility Questionnaire (Crandall, et.al. 1965)	.60-.74	test-retest & split-half
Non-verbal IQ (RAVEN)	Raven Progressive Matrices	.83-.97	test-retest
Basic Skills composite (COMPCTBS)	Canadian Tests of Basic Skills	.87-.95	split-half
Reading achievement (GMVOC (GMCOMPR)	Gates-MaGinitie Reading Tests; Vocabulary & Comprehension subtests, Survey D	.89-.95	split-half
*Attitude to school (ATSCH)	Semantic Differential	.83	test-retest
*Attitude to science (ATSCI)	Semantic Differential	.74	test-retest
*Student preference for treatment (PREF5) (PREF6) (CT1) (CT2)	Investigator designed SPI (student Preference Instrument) & independently assigned Choice Tasks	.71	test-retest

*developed for use in this study

Because so many instruments were employed in this study, they were administered at intervals to avoid a heavy load on the pupils. Each instrument was given to all classes at the same time. For standardized tests and instruments adopted from external sources, the following descriptions are based on readily available literature. For instruments modified or developed specifically for use in this study, the process of development is reported, and reliability and validity issues are discussed where appropriate.

3.41 Instruments adopted or modified from external sources

A Socio-Economic Index for Occupations in Canada (Blishen, 1967). This scale ranks 320 occupations characteristic of males in the labour force, based on 1961 Census data. The ranking is based on education and income levels of the members in these occupations. In this study, the father's occupation was obtained from school records for each pupil in the sample. Occupations were grouped into six categories on the basis of the Blishen Scale.

Self concept of ability. This scale was a slight modification of the Brookover (1962) questionnaire. It consisted of six five-choice items reflecting the general construct of self concept of ability in the school setting. The test-retest reliability of the modified scale was established at .72.

Dependence Proneness Scale. This scale was developed by Flanders, et.al. (1961), and consists of 45 agree/disagree items designed to measure subjects desire for help from others or to comply with group pressures. In the present

study, the variation in treatment was related to pupil freedom to make choices, and thus it seemed reasonable to postulate a relationship between this variable, treatment, and student attitude. The original authors reported a reliability coefficient of .68 for the scale. However, Elliot (1973) found a test-retest reliability of .91 in a context similar to the present study.

Children's Personality Questionnaire. This instrument was derived from Cattell's 16PF (Porter & Cattell, 1968) and was designed for use with young children. In the present study, the submissive/dominant scale only was used. The E factor of the CPQ which contains this subscale has a reported reliability of .74 to .82 by test-retest and parallel forms procedures.

Junior Eysenck Personality Inventory. The JEPI was developed by Eysenck (1963) to measure the two personality traits of neuroticism and extraversion. The 60 item scale contains three subscales, E, N, and L for measuring the two personality traits and detecting faked responses. The Maudsley Personality Inventory for adults, and the adult version of the Eysenck Personality Inventory were used as a construction basis for the JEPI. Validation of the instrument by comparing scale scores with symptoms of extraverted and introverted guidance clinic subjects has been reported by Eysenck (1964). Reliability estimates for the three subscales range from .70 to .80.

Intellectual Achievement Responsibility Scale. This scale was developed by Crandall, Katkovsky, and Crandall (1965) for

assessing a students belief that they, rather than other people are responsible for intellectual-academic successes and failures, (p 91). This variable was derived from social learning theory advanced by Rotter et. al. (1962). A student scoring high on the 29 item scale is said to be internal, i.e. tends to perceive positive and negative events as being consequences of his own actions and therefore under personal control. A low scoring student is rated as external, i.e. perceives positive and negative events as unrelated to his own behaviours and thus beyond personal control. It seems reasonable to postulate that students who tend to take responsibility for their own successes and failures (internals) will tend to like a teaching situation which is low in teacher controlling behaviours. Externals, who perceive reinforcements as controlled by the teacher and by other forces beyond their influence, should prefer a more structured situation.

Split half and test retest reliabilities for the scale are in the .60 to .74 range.

Raven's Progressive Matrices. Because of the availability of measures which were judged to be significantly correlated with verbal intelligence, and the concrete nature of the science activities, it was decided to employ a measure on non-verbal intelligence. This scale has a test retest reliability reported between .83 and .93, depending on subject age.

Canadian Tests of Basis Skills. A modified version of the Iowa Test of Basis Skills, this test battery measures general

intellectual skills in vocabulary, reading, language, work study and mathematics. The battery had been administered by the school district during the present study. Since separate vocabulary and reading scores were available from another instrument, only the composite score was used. Split half reliability estimates for the subscales of the CTBS vary from .87 to .97.

Gates-McGinitie Reading Test. Early in the study, information from the school board led the investigators to assume that scores on this widely used standardized reading test were available for all subjects. Subsequently it was found that only two schools had the information available. Administration of the test was carried out and adjustments made for the differences in times of administration. This method of obtaining comparable, complete data was judged more desireable than retesting the students who had already completed the test. Survey D, the form appropriate for this grade level, has reported reliability coefficients of .89 and .95 for the vocabulary and comprehension subtests respectively.

3.42 Instruments developed for use in the present study.

Previous science experience. Schools in the study differed widely in the amount and type of science taught prior to the investigation. This past experience could be a factor in determining a student's liking for experimental treatments. Accordingly, pupils were asked to respond to two items designed to measure the number of grades in which they had been taught science, and to assess their perceptions

of their previous science classes. The second item was a set of categories (Read book, Discuss book, Teacher demonstration, Activities) associated with degree of classroom structure. The pupil selected the one most descriptive of his previous science classes.

Attitudes to school and science. Ten pairs of bipolar adjectives were selected from the evaluative dimension of the semantic space (Osgood, et.al., 1957) for each of the concepts "school" and "science". A four point rating scale was used for each pair. Test retest reliability was .83 and .74 for the "school" and "science" concepts respectively.

Student Preference Instrument and Student Choice Tasks. As indicated earlier, the investigator was interested in the relationship of a sample of student characteristics with the liking for a set of teacher controlling behaviours used to define the treatments in the study. Most attitude related research has focussed on attitude gains in areas thought to be affected by the treatments, although in some cases the link is far from clear (Gardner, 1975). The present study sought specifically to relate affective outcomes to treatment characteristics.

The starting point for instrument construction was the treatment definitions (Table 1). For teacher training purposes, these definitions were written in a simplified format shown in Table 5. Twenty two items were constructed to solicit pupil preferences toward these variables (Appendix B). Table 5 also shows the numbers of the SPI item pairs related to each variable. The instrument was constructed

so that students reacted to a pair of items reflecting each variable. All items were worded positively, and the pattern of responses for each of the eleven pairs permitted the student to express his desire for more, less, or the same amount of teacher behaviour experienced in a particular treatment group. It was also possible to give an inconsistent response to a pair of items by indicating a desire for both more and less of a particular behaviour. Items in each pair were spaced eleven items apart, and the response pattern interpretations were alternated to avoid contamination of results by response set.

Table 5

Summary of simplified variables and related SPI items

Variable	High Control	Low Control	Related SPI item pair
1. Length of teacher-class introduction	long	short	(1,12)
2. Length of teacher-class summary and data interpretation	long	short	(2,13)
3. Ratio of soliciting to responding moves by teacher	high	low	(3,14)
4. Ratio of commands to requests by teacher	high	low	(4,15)
5. Ratio of substantive to controlling content in teacher-pupil interactions	low	high	(5,16)
6. Frequency of command performance with teacher as speaker	high	low	(4,15) (5,16)

Table 5 (continued)

Summary of simplified variables and related SPI items

Variable	High Control	Low Control	Related SPI item pair
7. Ratio of teacher-class to teacher-group interaction	high	low	(6,17)
8. Frequency of rating reactions by teacher	high	low	(7,18)
9. Number of teacher structuring moves of the give procedure type	high	low	(9,20)
10. Frequency of pupil reporting individual results	low	high	(8,19)
11. References to teacher requirements by teacher and pupils	high	low	(9,20)
12. References to expected outcomes by teacher and pupils	high	low	(10,21)
13. Wait time	short	long	(11,22)

The instrument was administered to both treatment groups at the end of each round, and in each case responses were made in the context of the treatment just completed. A score for liking high or low control teaching strategy was derived by considering the response pattern for each pair of items in the context of treatment just experienced. Table 6 illustrates the procedure for a sample pair of items.

Table 6

Scoring procedure for SPI items

SPI item pair	Response pattern		Liking score	
	Item 1	Item 12	Low Control	High Control
1. I would like the science lessons better if the teacher gave more directions at the beginning of the lessons	A	A	0	0
	A	D	1	3
	D	A	3	1
	D	D	2	2
12. I would like the science lessons better if the teacher gave fewer directions at the beginning of the lessons.				

A - Agree
D - Disagree

It was reasoned that a student who expressed a desire for more of a particular treatment behaviour had a stronger liking for that kind of treatment than one who agreed with the amount of behaviour experienced. Similarly, it seems reasonable to expect a student who wanted less of a certain behaviour experienced in a defined treatment liked that treatment less than the other two types discussed.

Inconsistent responses could have a number of different interpretations. Such a response consisted of two "agree" ratings for a pair of items, and could be the result of a

response set toward the left hand side of the choice list, a Pollyanna effect (Maguire, 1973) whereby respondents have a tendency to see good or agree with everything, or random marking of choices. The number of inconsistent responses, in any event, gives an indication of error in the instrument. A pilot study was conducted with a sample of 20 students randomly chosen from four classes. Analysis of the results gave 12% of the total responses inconsistent. Appendix G presents the inconsistency percentages by class for the main sample.

A quasi-interval scale for liking high control or low control teaching strategy was calculated by summing over all consistent responses for each subject and correcting for inconsistent responses. This was done by multiplying each score by the ratio of maximum score (33) to the maximum possible for each respondent (3 x number of consistent responses). The range of scores possible was from 11 (lowest liking for treatment type) to 33 (maximum liking for treatment type).

The reliability of the instrument was assessed using a test-retest procedure with a sample size of 30 students randomly selected from 5 classes. A time interval of one week elapsed, with a correlation of 0.71 resulting between corrected SPI scores.

The validity of the SPI scores can be discussed from three perspectives: construct validity, content validity, and consistency of results across treatments.

To assess the construct validity of a scale it is necessary to gather evidence from criteria thought to be logically related to performance on the scale. The SPI scale assumed to measure a students preference for learning in a particular situation, characterized by frequency of teacher controlling behaviours. It was decided to administer an independent, task oriented measure of student preference for treatment type.

A choice task was constructed for each treatment round, and administered at the end of each treatment. The choice given was between being assigned an activity of one class duration in which the purpose was identified and apparatus supplied but no specific directions given for procedure, data collection, etc. and the same activity in which a detailed worksheet was given to guide the student through the activity. These choice tasks and the directions given by the teachers during administration are presented in Appendix C. Once a student's choice was recorded, the activity was carried out in the chosen manner, in order to ensure that the decision was made with the understanding that the task would have to be carried out.

It was reasoned that a student who chose to do the activity in a mode consistent with the treatment he was experiencing would obtain a high liking score for that treatment on the SPI scale. Conversely, a student who chose to do the task in the method which was consistent with the opposite treatment, would get a low SPI liking score. A crosstabulation of choice task decision by student liking

treatment might give evidence for the construct validity of the SPI instrument. Although this procedure could not be used to improve the validity of the preference instrument prior to the study, it might yield an indicator of the instrument quality for future applications.

A scale is said to have content validity if it appears to measure what it is intended to measure. The SPI scale was derived directly from the definitions explained to the teachers for differentiating the two teaching conditions. It was assumed, and table 7 in the analysis section gives a check on this assumption, that teacher behaviours in the high and low control classes would differ according to these definitions. Hence, it appears to be a valid procedure to assess student liking for the teacher behaviours intended to characterize the treatments. As table 5 shows, the variables in the treatment definitions are fairly represented by items on the SPI scale.

The design of this study permits a further check on the validity of the SPI instrument. Liking for high control teaching strategy is analyzed independently from liking for low control strategy. It seems reasonable to expect that if a particular type of student expresses a high liking for one kind of treatment, he would not express a high liking for the other. If the instrument is indeed measuring liking for teacher controlling behaviours, this should be the case. If SPI scores reflect measures of other unknown constructs, and evidence shows that treatments have been reasonably operationalized, students may show high or low liking for both types

of treatments. Thus, an assessment of the consistency of outcomes can be taken as an indication of the SPI instrument construct validity.

3.5 Data analysis

The question of which control strategy is generally preferred in the study sample is not central to this investigation but can be tested by the Student's statistic. The SPI mean scores for the two treatments were tested for both round 1 and round 2 and examined for consistency.

Multiple linear regression analysis was used to investigate the more central question of relationships of student characteristics measured in the study to the preference criterion. It was decided to use the student as the unit of analysis, despite the arguments advanced by Cronbach (1976) that observations made on idividuals within a class are nonindependent. Although this study used intact classes, the problem of class effects was considered to be not as great as is usually assumed since most of the class time was spent at the small group level rather than at the whole class level. Also, the special project teachers taught both treatments, tending to disrupt any special teacher-class coherence that might exist with regular teachers.

The pool of independent measures were first analyzed by generating their intercorrelation matrix; and then a crossbreak procedure, which tested for the independence of each separate variable and the SPI scores. Variables which displayed no relationships with the preference criterion were excluded from further analysis by the multiple linear

regression procedure. Variables which were selected in this manner were further inspected for high intercorrelation. The variable judged to be the best potential predictor was selected from any subset of highly intercorrelated measures of the same construct.

Regression analyses were performed separately for both treatment groups within a round. This permitted two kinds of comparisons: (1) effectiveness of predictor variables for the sample of round 1 with the sample of round 2; for both liking high control and liking low control (2) effectiveness of predictor variables for a particular sample in predicting liking for high control and liking for low control. Consistency of results in terms of significance and direction supports the validity of the SPI instrument.

Choice task data yielded nominal data only, and was analyzed by means of a series of Chi-squared tests based on the frequencies of choice for each treatment tabulated by blocked attribute variables. The relationship of each independent variable to the criterion was thus analyzed separately, instead of in the presence of the others as was done in the regression analyses. Choice task data was also crosstabulated with preference scores and examined for consistency of choice with expressed preference in a further test of the SPI instrument validity.

IV EXPERIMENTAL RESULTS

4.0 Overview

The purpose of this study, as discussed earlier, was to investigate the effects of variations in teacher behaviour, specifically that aspect of behaviour that has been termed "teacher control". The study was designed to test hypotheses regarding (1) pupil preferences in the two treatment groups; (2) the relationships between student characteristics and student preference for (a) high control teaching strategy; and (b) low control teaching strategy; and (3) to collect data on the validity of a preference measuring instrument.

This chapter presents the findings of the study. The presentation takes the following order:

1. treatment implementation data
2. crossbreak analyses of SPI data
3. summary of research hypotheses
4. regression analyses of selected variables
5. comparison of student preference for treatment
6. crossbreak analyses of choice task data
7. SPI validation data
8. summary of results

4.1 Treatment implementation data

Table 7 summarizes the variables on which teachers were expected to differ in implementing high and low control treatments. The implementation check sample was approximately 130 minutes of lesson time for each treatment, and included each teacher at least once in each treatment. Units are in accordance with the modified Bellack coding system (Crocker, et.al., 1975, Ch. 6)

In general, the differences were in the direction desired. However, essentially no differences were observed in the sample

for teacher responding and reacting moves. Also, it was anticipated that the difference for the soliciting moves would be larger than sampled. One variable, pupil reporting of individual results, gave a result in the opposite direction from that predicted.

As a further check on treatment implementation, an analysis of teacher behaviours by treatment and teacher is given in table 8. Despite the training given to the study teachers and the uniformity of content, it was supposed that the teachers would not all operationalize the treatments to the same degree. As can be seen by comparing tables 7 and 8, the inter-teacher differences within a treatment are at least as great as inter-treatment differences. It could thus reasonably be expected to find that teacher effects on dependent variable measures would be important.

4.2 Crossbreak analysis of SPI data

Crossbreak analyses were performed for each of the independent variables in the study. While this method of analysis is less powerful than other forms, and ignores intercorrelations between variables, it does give a fairly clear picture of the relationship of each individual variable with the criterion. With the exception of teacher and sex, variables were trichotomized with cutting points established at the 33rd and 66th percentiles of the sample distribution. Information yielded by this analysis

Table 7

Comparison of behaviours in high and low control treatments

variable	high control	low control
Teacher-class interaction	876	419
Teacher-group interaction	671	1,095
Proportion of pupil talk during teacher-class interaction	0.06	0.10
Proportion of pupil talk during teacher-group interaction	0.24	0.29
Teacher structuring	453	369
Teacher soliciting	539	650
Teacher responding	89	*84
Teacher reacting	229	*227
Ratio of commands to total solicits	0.69	0.79
Pupils reporting individual results	76	*46
Teacher substantive-logical discourse	187	230
Pupil substantive-logical discourse	34	55
Average wait time	1.5	1.9

* Round 2 data only

Note: Except for ratios, units are total number of sentences uttered for the check sample.

Table 8

Treatment by teacher comparisons for selected teacher behaviours

Variable	Treatment	Teacher 1	2	3	4
Teacher-class interaction	HC	12	26	18	30
	LC	9	8	15*	11
Teacher-group interaction	HC	26	17	7	7
	LC	26	27	13*	29
Teacher structuring	HC	11	10	8	12
	LC	8	9	15*	7
Teacher soliciting	HC	11	14	11	15
	LC	15	15	6*	19
Ratio of commands to total solicits	HC	.36	.29	.40	.27
	LC	.21	.24	.54*	.17
Teacher reacting	HC	4	11	4	2
	LC	3	8	8*	5

*Round 2 data only

Note: Except for ratios, units are mean number of sentences uttered during a three minute segment.

was used to identify variables which were possible significant predictors for preference. These variables were later analyzed using multiple linear regression techniques.

Table 9 summarizes the crossbreak results. The Chi-square test revealed significant relationships for eleven different variables, but only three of these replicated across rounds within a treatment. These were the relationships of preference with SES, ability (COMPCTB), and with teachers. Pupil ability as measured by the Canadian Tests of Basic Skills (COMPCTB) remained consistent both across samples within a treatment, and across treatments within a sample, with high ability students expressing a low liking for high control and a high liking for low control. High SES students tended to express a high liking for the low control treatment in both rounds. A significant dislike for high control was expressed in round 2 by high SES students. Teacher 1 appears to have contributed most to the significant teacher by preference relationship. This teacher's pupils tended to like her low control classes and dislike her high control classes to a greater extent than was expressed in other classes. However, teacher 1 taught two classes in both treatments.

Within a given sample across treatments, SES, ability (COMPCTB) experience (YEX) with science, and teacher effects remained consistent for the groups which switched from low control to high control, whereas ability (GMVOC), (COMPCTB) was the only stable effect for the group experiencing the opposite change in treatments.

Table 9

Summary of crossbreak results for SPI scores

Independent Variables	Low control treatment						High control treatment					
	Round 1			Round 2			Round 1			Round 2		
	X^2	DF	P	X^2	DF	P	X^2	DF	P	X^2	DF	P
SEX	9.40	2	.01	3.61	2	NS	1.15	2	NS	1.58	2	NS
SES	7.95	4	.10	9.29	4	.10	5.03	4	NS	22.85	4	.001
RAVEN	5.83	4	NS	3.72	4	NS	9.18	4	.10	4.21	4	NS
GMVOC	5.70	4	NS	14.56	4	.01	24.79	4	.001	6.84	4	NS
GMCOMPR	3.76	4	NS	5.95	4	NS	13.33	4	.01	5.76	4	NS
COMPCTBS	11.02	4	.05	26.09	4	.001	28.38	4	.001	19.27	4	.001
EXTRA	12.00	4	.05	3.14	4	NS	6.47	4	NS	5.48	4	NS
NEURO	3.80	4	NS	4.14	4	NS	1.26	4	NS	5.84	4	NS
SUBDOM	12.66	4	.05	7.45	4	NS	9.12	4	.10	4.87	4	NS
DPS	4.16	4	NS	4.05	4	NS	2.08	4	NS	5.94	4	NS
IAR	2.29	4	NS	6.66	4	NS	7.03	4	NS	4.21	4	NS
SCONA	5.83	4	NS	5.27	4	NS	4.94	4	NS	2.33	4	NS
YEX	10.81	4	.05	4.01	4	NS	2.68	4	NS	16.77	4	.01
ATSCH	1.43	4	NS	4.11	4	NS	5.65	4	NS	3.92	4	NS
ATSCI	4.86	4	NS	9.71	4	.05	4.09	4	NS	3.07	4	NS
TEACH1,2	21.99	4	.001	8.44	6	NS	26.33	4	.001	32.50	6	.001

The effects of SES and ability were in the expected direction, with a given sample of high SES and high ability students expressing a high liking for low control in round 1 and a low liking for high control in round 2. For the experience variable (YEX), it was revealed that pupils with more years of experience with science tended to like low control treatment.

4.3 Summary of reserach hypotheses

Multiple linear regression is a useful procedure for evaluating the combined contribution of a set of independent variables in explaining variance in a given dependent measure. Of more importance to the present study is the ability of this technique to assess the contribution of a given variable or block of variables to the variance in a dependent measure while controlling for the confounding influence of other independent variables. As an attractive feature, variables do not have to be blocked, with consequent loss of power (Cronbach & Snow, 1977), as they do in other forms of analysis.

Of the eleven variables first identified from table 9 as potentially significant predictors of student preference, four were highly correlated measures of pupil ability (see Appendix H). The composite score for the Canadian Tests of Basic Skills, COMPCTBS, was retained as the measure for pupil ability, while RAVEN, GMVOC, and GMCOMPR were deleted. This procedure was followed since in ordinary regression, variance is shared by correlated measures of the same construct.

Including four measures of ability would thus bias the regression results in favour of uncorrelated variables with fewer measures in the equation (Gordon, 1968). In an hierarchical regression procedure, variables are entered on the basis of their ability to explain variance not already explained by variables previously entered. Highly correlated measures on the same construct would again serve no purpose, since it is unlikely that a significant increase in the multiple correlation would result from these variables after the entry of the best predictor.

The other variables retained for the regression analysis were the pupil background variables, SES, SEX, YEX and ATSCI; personality variables SUBDOM and EXTRA; and the teacher variable TEACH1,2.

The following specific research hypotheses were formulated:

H1: There is no linear relationship between student preference for learning in the low control treatment and the set of variables used in the study.

H2: There is no linear relationship between student preference for learning in the high control treatment and the set of variables used in the study.

After variability due to teacher and other independent variables is controlled for, it is hypothesized that:

H3: Sex has no linear effect on preference for
A. low control
B. high control

H4: SES has no linear effect on preference for
A. low control
B. high control

H5: Ability has no linear effect on preference for
A. low control
B. high control

H6: Extraversion has no linear effect on preference for
A. low control
B. high control

H7: Dominance has no linear effect on preference for
A. low control
B. high control

H8: Experience with science has no linear effect on preference for
A. low control
B. high control

H9: Prior attitudes toward science have no linear effect on preference for
A. low control
B. high control

In addition, the following set of hypotheses was tested:

H10: Pupil ability does not add significantly to variation in pupil preference already explained by teacher variation for
A. low control
B. high control

H11: Pupil background variables (sex, ses, experience with science, prior attitude toward science) do not add significantly to variation in pupil preference already explained by teacher and pupil ability variation; for
A. low control
B. high control

H12: Pupil personality variables (extraversion, dominance) do not add significantly to variation in pupil preference already explained by teacher variation, pupil ability, and background variables; for
A. low control
B. high control

Finally, the general hypothesis below was tested.

H13: Pupil preference for learning in low control settings is not significantly different from pupil preference for learning in high control settings.

4.4 Regression analyses of selected variables

Two regression procedures were used to test the two sets of specific hypotheses H1 through H12.

To test the first group of hypotheses H3 to H9, teachers were entered first into the regression equation in stepwise fashion, followed by the simultaneous entry of the remaining variables.

The second set of hypotheses H10 to H12 were tested with an hierarchical regression procedure, with the following variable entry order:

1. teachers (T1, T2, T3)
2. ability (COMPCTB)
3. background variables (SEX, SES, YEX, ATSCI)
4. personality variables (SUBDOM, EXTRA)

Using the first procedure, it was possible to assess the individual relationship of a given variable to the students' preference scores while controlling for the effects of the other variables and variation of teachers within treatments. The second procedure could be used to test the significance of contributions of subsets of variables to the explained variance in student preference. The significance of total explained variance (H1 and H2) could be tested by either procedure.

Regression results

Hypotheses H1 and H2. Table 10 shows the predictive power achieved for each analysis using the entire set of predictors selected for the study. Multiple R values were significantly different from zero at the 1% level of

confidence for all but the low control, round 2 group. Hypothesis H2 was thus rejected. Rejection of H1 is not possible since the result did not replicate across samples, and hence must be considered unstable.

Hypotheses H3 to H9. Table 11 summarizes the results of the regression analysis performed to test these hypotheses. Changes in the square of the multiple correlation upon the entry of a given variable into the regression equation containing all the others were compared to the residual sum of squares corrected for the appropriate degrees of freedom. The F statistic produced in this manner was then examined for significance.

H3A,B. Both of these hypotheses were accepted. Moderate but non-significant sex effects occured in the low control treatment for both rounds, and in the first round of the high control treatment.

H4A,B. Both of these hypotheses were accepted. A moderate but non-significant SES effect occured in round two of the high control treatment, with high SES students expressing dislike with this treatment.

H5A,B. Both of these hypotheses were accepted. However, a strong ability effect was observed in the high control treatment of the first round, and a moderate effect observed for the same sample in the round two low control treatment. The direction of the effect was consistent across rounds, with the high ability students expressing dislike for high control in round 1, and liking for low control in round 2. Since the effect was not stable across samples, however,

Table 10

Overall F. test for regression analyses

Round 1 Low Control

Multiple R	0.518	ANOVA	DF	Sum of Squares	Mean Square	F
R^2	0.268	Regression	9	284.31	31.59	2.93
Std. Error	3.285	Residual	72	777.22	10.79	**

Round 2 Low Control

Multiple R	0.321	ANOVA	DF	Sum of Squares	Mean Square	F
R^2	0.103	Regression	10	202.89	20.29	1.37
Std. Error	3.842	Residual	120	1771.00	14.76	

Round 1 High Control

Multiple R	0.471	ANOVA	DF	Sum of Squares	Mean Square	F
R^2	0.222	Regression	10	427.92	42.79	3.60
Std. Error	3.449	Residual	126	1498.71	11.89	**

Round 2 High Control

Multiple R	0.536	ANOVA	DF	Sum of Squares	Mean Square	F
R^2	0.287	Regression	10	414.21	41.42	3.02
Std. Error	3.702	Residual	75	1027.64	13.70	**

** $p < .01$

Table 11

Summary of regression analyses for H3 to H9

Source	Low Control Treatment				High Control Treatment			
	Round 1[a]		Round 2[b]		Round 1[c]		Round 2[d]	
	ΔR^2	F	ΔR^2	F	ΔR^2	F	ΔR^2	F
Teacher 1	0.121	11.90***	0.021	2.74*	0.045	7.30***	0.180	18.90***
Teacher 2	0.008	0.81	0.002	0.33	0.049	7.97***	0.001	0.13
Teacher 3†			0.008	1.12	0.018	2.84*	0.027	2.82*
Sex	0.041	2.46	0.002	1.93	0.003	1.30	0.008	0.10
SES	.001	0.03	0.002	0.06	.001	1.18	0.039	2.61
Ability	0.009	0.23	0.040	3.04*	0.083	13.83***	0.015	1.70
Extraversion	0.048	3.40*	.001	0.03	0.011	1.81	.001	0.03
Dominance	.001	0.02	0.013	2.95*	0.008	1.57	0.001	0.11
Experience	0.023	1.90	0.003	0.35	0.003	0.61	0.017	1.75
Attitude	0.016	1.58	0.011	1.45	0.002	0.34	.001	0.03

*** $p < .01$
** $p < .05$
* $p < .10$

[a] $N = 82$ DF = 1, 72
[b] $N = 131$ DF = 1,120
[c] $N = 137$ DF = 1,126
[d] $N = 86$ DF = 1, 75

† teacher 3 did not teach a low control class in round one

Table 12

Summary of regression analyses for H10 to H12

Source	Low Control Treatment						High Control Treatment					
	Round 1[a]			Round 2[b]			Round 1[c]			Round 2[d]		
	ΔR^2	F	DF	ΔR^2	F	DF	ΔR^2	F	DF	ΔR^2	F	DF
Teachers TEACH1,2,3	.129	5.87 **	2,79	.031	1.37 NS	3,127	.112	5.58 **	3,133	.208	7.34 **	3,84
Ability COMPCTB	.013	1.16 NS	1,78	.041	5.59 *	1,126	.076	11.32 **	1,132	.024	2.56 NS	1,83
Background SEX, SES, YEX, ATSCI	.084	2.00 NS	4,74	.008	0.26 NS	4,122	.012	0.49 NS	4,128	.055	1.52 NS	4,79
Personality SUBDOM EXTRA	.042	2.07 NS	2,72	.022	1.49 NS	2,120	.022	1.79 NS	2,126	.001	0.11 NS	2,77

** $p < .01$

* $p < .05$

[a] N = 82

[b] N = 131

[c] N = 137

[d] N = 86

the hypotheses were accepted.

H6A,B. Both of these hypotheses were accepted. A moderate significant extraversion effect was observed in the low control treatment of round one, with extraverts expressing a preference for this treatment. However, the effect was not observed in round two, so H6A was accepted. The low multiple R observed in low control, round two made all findings for this group tenuous.

H7A,B. Both of these hypotheses were accepted. A moderately significant dominance effect occurred in the round two, low control treatment. The slight dominance effect for the same sample in the round one high control group was consistent with this, with dominant students tending to like low control settings.

H8A,B. Both of these hypotheses were accepted. The moderate but non-significant effects observed for the sample in round one low control and round two high control were inconsistent, with pupils with more years of science expressing liking for the high control in the first instance, and low control in the second round.

H9A,B. Both of these hypotheses were accepted. The slight but non-significant effects observed for round one and round two low control replicated, in that students with positive prior attitude toward science tended to prefer the low control treatment.

Hypotheses H10, H11, and H12. It is immediately apparent that teacher effects were quite strong and replicated across both rounds. Teacher 1 accounted for most of this

effect (teacher 4 was used as the reference category in the dummy variable coding required for this variable) and examination of the regression weights indicated that high liking was expressed in this teacher's low control classes, and low liking was associated with her high control classes. Teacher 3 displayed a moderate effect across both rounds in the high control treatment only. The sign of this teacher's regression weights indicated that her high control treatment was not liked in the first round, but was liked by the sample in the second round. Since only one class of the high control treatment was taught by this teacher in each round, this inconsistency is perhaps due to special class effects.

The regression results summarized in table 12 show that after variability due to teachers within a treatment is accounted for, only one subset of variables can add significant additional explanatory power to the regression equation. Pupil ability in round one high control, and round two low control increased the multiple correlation coefficient significantly. Entry of the pupil background variables or personality variables did not make a significant contribution to the explained variation over and above that attributed to teachers and pupil ability. However, since the ability effect did not replicate across samples, H10A,B was accepted. Finally, since no significant effects were found to support their rejection in either treatment of either round, H11A,B and H12A,B were accepted.

4.5 Comparison of student preference for treatment

Table 13 summarizes the comparisons between student

preference for the two treatments in both round one and round two. The table shows that students expressed a significant preference for the low control treatment. This finding was consistent across rounds. The test used for significant differences between sample means was a modification of the Student's t statistic (Nie, et.al. 1975). Thus H13 was rejected.

Table 13

Comparison of student preference for treatment

Round	Treatment	Sample size	Mean	Standard deviation	standard error	t-Value	Significance level
1	HC	212	21.23	3.93	0.27	2.93	<.01
	LC	124	22.53	3.95	0.35		
2	HC	129	21.11	4.08	0.36	4.79	<.001
	LC	204	23.33	4.13	0.30		

4.6 Crossbreak analyses of choice task data

The distributions of pupil choice of structured and unstructured mode tasks are shown in table 14. It is obvious that pupils displayed a strong tendency to choose the unstructured task. This was consistent with the significant finding reported for pupil preference data as measured by the SPI instrument. A breakdown of the choice information shown in table 15 indicates that student choice is essentially independent of the treatment the student was in at the time the decision was made. One interesting result was that a fairly large number of pupils changed their choice in favour of the unstructured task in the second round. Perhaps this

was due to their having experienced the procedure before and were thus more clear on the alternatives. However, there was no way to confirm this speculation from the data.

Table 14

Frequencies of pupil choice for structured and unstructured tasks

each treatment of each round were performed. Preference scores were blocked into low, medium and high categories. The 33rd and 66th percentiles were selected as cutting points. The results are displayed in table 16. Preference scores and pupil choice do not display evidence of relationship. Pupils persisted in selecting the low structure task even though they indicated low preference for being taught in the low control treatment. By examining only those categories of high and low preference, and omitting the medium category, it is seen that the number of students making the choice consistent with their expressed preference is roughly equal to the number making an inconsistent response. Collapsing the two treatments across rounds yields 102 consistent and 91 inconsistent responses in the high control treatment; 96 consistent and 104 inconsistent responses in the low control treatment. It appears from this evidence that the total SPI score data and the choice task data are statistically independent.

A summary of the crosstabulation results of student choice with student characteristics and with teachers appears in table 17. Nonindependence as indicated by the Chi-square value, can be taken as evidence of relationship. These tests are particularly stringent since the sample has been analyzed by treatment and round. Significant results across two rounds within a treatment amounts to a replication of the finding with two different samples of students. Significance of findings across treatments within a sample amounts to evidence of a stable result for

Table 16

Frequency comparisons of pupil choice for structured and Unstructured tasks by preference for treatment

Round	Preference	Low Control Treatment				High Control Treatment			
		Chose Unstructured		Chose Structured		Chose Unstructured		Chose Structured	
		O	(E)	O	(E)	O	(E)	O	(E)
1	Low	17	$(17)^{I}$	12	$(12)^{C}$	38	$(41)^{C}$	35	$(32)^{I}$
	Medium	28	(23)	11	(16)	44	(41)	28	(31)
	High	26	$(30)^{C}$	24	$(20)^{I}$	25	$(25)^{I}$	19	$(19)^{C}$
			$X^2 = 3.62$ DF = 2; NS				$X^2 = 1.21$ DF = 2; NS		
2	Low	37	$(34)^{I}$	11	$(14)^{C}$	39	$(41)^{C}$	15	$(13)^{I}$
	Medium	47	(45)	16	(18)	32	(30)	7	(9)
	High	47	$(52)^{C}$	26	$(21)^{I}$	16	$(17)^{I}$	6	$(5)^{C}$
			$X^2 = 2.82$ DF = 2; NS				$X^2 = 1.31$ DF = 2; NS		

C - consistent response

I - inconsistent response

Table 17

Summary of Chi-square tests for pupil choice of structured and unstructured tasks by pupil characteristics

Variable	Low Control Treatment						High Control Treatment					
	Round 1			Round 2			Round 1			Round 2		
	X^2	DF	P	X^2	DF	P	X^2	DF	P	X^2	DF	P
SEX	0.86	1	NS	4.82	1	< .05	11.84	1	< .001	9.77	1	< .01
SES	0.26	2	NS	3.05	2	NS	4.40	2	NS	0.38	2	NS
RAVEN	4.53	2	NS	0.43	2	NS	3.70	2	NS	0.75	2	NS
GMVOC	10.62	2	< .01	4.42	2	NS	5.15	2	< .10	2.92	2	NS
GMCOMPR	5.53	2	< .10	4.13	2	NS	5.24	2	< .10	1.12	2	NS
COMPCTBS	0.72	2	NS	4.94	2	< .10	8.25	2	< .05	0.22	2	NS
EXTRA	1.49	2	NS	1.61	2	NS	2.04	2	NS	1.59	2	NS
NEURO	0.97	2	NS	4.54	2	NS	6.70	2	< .05	0.06	2	NS
SUBDOM	8.92	2	< .05	10.39	2	< .05	6.28	2	< .05	7.86	2	< .05
DPS	4.82	2	< .10	3.82	2	NS	3.02	2	NS	3.29	2	NS
IAR	5.29	2	< .10	3.26	2	NS	1.37	2	NS	4.26	2	NS

Table 17 (continued)

Summary of Chi-square tests for pupil choice of structured and unstructured tasks by pupil characteristics

Variable	Low Control Treatment						High Control Treatment					
	Round 1			Round 2			Round 1			Round 2		
	X^2	DF	P	X^2	DF	P	X^2	DF	P	X^2	DF	P
SCONA	4.15	2	NS	10.71	2	$<.01$	3.07	2	NS	0.84	2	NS
YEX	2.80	2	NS	6.98	2	$<.05$	2.87	2	NS	3.08	2	NS
ATSCH	1.91	2	NS	1.89	2	NS	1.40	2	NS	0.37	2	NS
ATSCI	2.49	2	NS	1.87	2	NS	1.23	2	NS	2.37	2	NS
TEACH1,2	1.33	2	NS	4.76	2	NS	13.80	3	$<.01$	21.00	3	$<.001$

a particular population. This particular breakdown was used to parallel the crossbreak and regression analyses with the SPI data for later comparison.

Strong sex and dominance effects, as well as a significant interaction with teacher, are evident from table 17. The sex and teacher effect replicate across rounds only for the high control treatment, but the dominance effect is repeated for both treatments. The highly correlated (.77) vocabulary and reading comprehension variables appeared to interact moderately with choice in round one, but this effect was not evident in round two. Effects that appeared only once, such as those for self concept (SCONA) and experience (YEX) cannot be considered stable enough to represent meaningful findings. The pupil ability measure (COMPCTB) remained consistent across treatments within the sample which began in high control round one and changed to low control in the second round.

Examination of the frequencies in the crossbreak cells showed that in contrast to the finding that boys tended to prefer low control reported under the regression analysis section, girls tended to choose the unstructured task more often than boys.

The dominance effect was fairly clear, with submissive students tending to choose unstructured tasks more often. This contrasts with the regression finding for extraversion, a correlated measure, which indicated that extraverts tended to prefer low control settings.

Teacher effects are less clear, with choice for unstructured task predominating in teacher one and teacher

two low control classes; in teacher two and teacher four high control classes. Choice for unstructured task is perhaps most uniquely associated with teacher two.

The correlated ability measures also yielded findings which conflicted with the regression results. Low ability students tended to choose the unstructured task more often than higher ability students, but the results of the SPI score analysis indicated that high ability students preferred low control, while low ability students preferred high control.

These differences indicate, as discussed earlier, that the choice task and student preference instrument are unrelated measures. It seems that the choice expressed on pen and paper instruments may not be reflected in action, in this analysis. Students may perceive that proceeding in a structured approach leads to higher achievement, and their choice of this approach may be based on such practical considerations. Dominant and highly intelligent students might well be better aware of such considerations and thus make choices more dissonant with their expressed preferences.

4.7 SPI validation data

As a check on the stability and consistency of the SPI instrument, zero order correlations were calculated between the SPI scores and each of the independent measures. Stability of correlation direction across rounds and consistency of samples within a treatment indicates that the instrument scores are systematically related to the attribute variables. A change in correlation direction (sign) from one treatment to the other

indicates that high liking for low control is coupled with low liking for high control as expressed on the instrument.

Table 18 summarizes the correlations. Round one and round two samples in both treatments display consistency of the first type in all but two cases of the low control treatment; SEX and DPS, both of which have non significant correlations in one or both rounds.

Consistency of the second type is noted by comparing round one high control with round two low control, and round one low control with round two high control. Consistency in this case is indicated by a change in sign of the correlation coefficient. This was observed in all but four instances, in which non-significant correlations were involved.

Finally, if the SPI instrument is measuring consistently, preference scores from the first round (DPREF5) should be significantly negatively correlated with preference scores in the second round (DFREF6), since each student changes treatments. In order for the preference scores to be stable, a student who expresses a desire to be taught in a mode different from the treatment being experienced (low liking) should express liking for the opposite treatment type. A correlation of -.444 was observed for the 310 subjects who completed the instrument in both rounds. This value was significantly different from zero at the .001 level of significance.

4.8 Summary

Data were presented to support the distinction between treatments as actually implemented by the teachers. In

Table 18

Zero order correlations of SPI scores with independent variables

Variable	Low Control Treatment		High Control Treatment	
	Round 1	Round 2	Round 1	Round 2
SEX	-0.2499	0.0529*	0.0199*	0.1681*
DSES**	-0.2649	-0.1626	0.1385	0.4139
DRAVEN	0.2339	0.1005*	-0.2283	-0.2487
DGMVOC	0.1939	0.2102	-0.2734	-0.3050
DGMCOMPR	0.2364	0.1627	-0.2342	-0.3039
DGMCOMPCTB	0.3181	0.2902	-0.3544	-0.3358
DEXTRA	0.3098	0.1345*	-0.0975*	-0.2273
NEURO	-0.1612*	-0.0455*	0.0082*	0.1353*
SUBDOM	0.2794	0.0881*	-0.2331	-0.2287
DPS	-0.0502	0.1109*	0.0185*	0.1205*
IAR	-0.0467*	-0.0464*	0.0631*	0.2234
SCONA	0.2680	0.1681	-0.1089*	-0.2036
YEX	0.2008	0.0099*	-0.1460	-0.3080
ATSCH	-0.0603*	-0.0131*	0.1290*	0.1048*
ATSCI	0.0244*	0.0860*	0.0700*	0.1082*

* not significant at the p = .05 level

** SES scored such that low value corresponds to High SES

general, the differences observed were in agreement with the definitons, however, interteacher variation within treatments was of the same order as intertreatment variations. This led to large teacher effects on the criterion.

The independent variables available to the study were explored using a crossbreak procedure. Several significant effects emerged, and variables were selected for further analysis by the multiple linear regression procedure. The variables selected formed a significant set of predictors for student preference in all but one of the rounds of low control treatment. However, when the criterion of stability across rounds was invoked, none of the selected variables was significantly related to student preference after teacher variation and the other variable effects were controlled.

Subsets of variables were tested for relationship with the student preference in an hierarchical regression procedure. It was found that neither pupil personality, background, nor ability could explain significant variation in student preference after teacher variation was accounted for. There was some evidence that pupil ability could explain additional variation, but this was dismissed on the basis of lack of stability across rounds.

A strong general preference for learning in the low control setting was expressed by students of both rounds. The hypothesis that there was no significant difference in general preference was hence rejected.

A choice task administered in both rounds of the two

treatments yielded data which was nominal in nature. A crossbreak procedure was used to analyze the data, and it was found that students displayed a strong tendency to choose tasks classified as unstructured. This supported the earlier finding for student preference as measured on the SPI instrument. Several non-independent relationships were found when the choice task data were subjected to the Chi-square test. However, when the criterion of stability across rounds was invoked, only sex, dominance, and teacher effects were considered significant. The direction of the relationships was particularly interesting, with girls and submissive students choosing the unstructured tasks more frequently than higher ability students. These findings contrasted with the trends observed in the SPI data on student expressed preference.

The original purpose of the choice task was to provide an independent measure of student preference. However, the SPI data and student choice data were essentially independent, as determined by the Chi-square test. Student expressed preference and student action in a concrete situation appeared to be not necessarily related.

Zero order correlations of student attribute measures with SPI scores were calculated as a check on the stability and consistency of relationships between these attributes and expressed preference. It was concluded that the observed relationships were stable and consistent on the basis of this analysis.

V SUMMARY AND CONCLUSIONS

5.0 Summary of purposes and methodology

This study was concerned with variations in teacher controlling behaviours within the specific context of elementary science classes. The theoretical and practical importance of the teacher control continuum in classrooms has been outlined previously. Two experimental treatments were defined in terms of selected categories from a classroom observation system to represent the poles of this continuum. These were designed within the practical limits imposed by specific curriculum, its associated materials, and lesson format derived from that curriculum (pupils working in small groups).

The experimental design included the use of both treatments in all classes in an alternating sequence to permit a replicated analysis, the use of special teachers to allow teacher training, the balanced assignment of teachers to classes, and the monitoring of treatments implementation through the use of videotapes and the coding of those teacher behaviours used to define the treatments.

An instrument was designed to measure student preference for the teacher behaviours characterizing the treatments. The student responded to this instrument at the end of each round within the context of the immediate treatment. Thus it was possible to get a measure of his preference for control in relation to the control situation he was experiencing. The experimental design permitted a comparison of pupil attribute-preference relations across treatments within a sample for consistency, and across rounds within a treatment for

stability.

An independent assessment of student preference was administered in the form of a concrete choice task. This was intended to corroborate findings based on the preference instrument data. Crossbreak analyses and X^2 tests were used on the choice task data and in initial screening of pupil attribute variables for subsequent regression analyses.

5.1 Summary of findings and conclusions

1. In general, teachers operated in a mode consistent with the operational definitions of the treatments. However, differences between teachers were sufficiently great to lead to significant teacher effects in the crossbreak analyses for SPI and choice task data, and in the regression analyses.

2. Statistically significant differences in preferences for high and low control were observed on both the SPI measures and choice task data. In all cases, a stronger preference for low control was recorded. This is in agreement with findings summarized by Dunkin and Biddle (1974), Flanders (1970), Stallings (1974). Crocker, et.al. (1976) reported a significant finding in favour of structured approach, and Rian (1969) reported no significant relationship between pupil satisfaction and teacher indirectness. The findings of the present study seem to be in agreement with the larger body of research.

3. The findings for relationships between pupil attributes and preference were disappointing. When teacher variability was removed, and other independent variables controlled for using a multiple linear regression procedure, none of the

variables survived the criterion of stability across samples in order to qualify as a significant finding. Taken as a set, the variables did predict a significant amount of variance in the preference criterion in all but round two, low control. When analyzed in subsets, the results were again disappointing, with neither pupil ability, background, nor personality variables significantly contributing to explained variance in the preference criterion after teacher variability was controlled.

If the rule of stability of findings across samples and consistency within samples is relaxed for purposes of discussion only, some of the results may be related to findings in previous research.

A consistent effect was observed for ability with the sample which began in high control round one, and changed to low control round two. High ability students expressed a consistent preference for low control. This is in agreement with Crocker (1976) who reported that high IQ students expressed a stronger preference for structured strategy than low IQ students. Babikian (1971) reported that low IQ students rated an expository method as significantly better than a discovery method, whereas high IQ students expressed no preference.

Extraversion and dominance effects which did not replicate indicated that dominant pupils and extraverted pupils tended to prefer low control. Stanton (1974) reported no relationship between extraversion and pupil preference for teaching method. Crocker (1976) also reported no significant relationships with this variable. Dominance was highly correlated with dependency

(-.44) for this sample. Several studies (Covington, 1972; McKeachie, 1958; Wispé, 1951) reported that dependent students preferred structured learning situations. Others (Crocker, 1976; Tuckman, 1968) found that dependency was unrelated to pupil preference.

4. Choice task findings did not corroborate the results of the preference instrument. Pupil choice was essentially independent of expressed preference. Furthermore, the direction of the attribute preference relationships for the choice task data were in the opposite direction to trends observed with the SPI data. This suggests that student feelings toward a particular teaching style or behaviour as expressed on a pen and paper instrument may not be as accurate a predictor of his behaviour in certain instances as we might suppose. It could well be that in a situation where a student is faced with a choice between two alternatives, one logically congruent with his previously expressed preference and one not, other factors such as need to achieve, perceived possibility of success, etc. may become operant. Further research would be required to substantiate such speculations.

5. The preference instrument measured consistently within a sample. This means that if a particular attribute was positively correlated with liking for low control, for example, then it was negatively correlated with liking for high control. Stability was also observed for the instrument. This was demonstrated by the fact that correlations between attribute measures and preference measures were in the same direction for two different samples of students for both high and low control. Although the choice task data did not

corroborate SPI data, the directional stability and consistency of significant effects observed using the instrument provide some evidence for its validity. The scoring procedure used with the instrument also incorporated an indicator of inconsistency as discussed earlier. The average inconsistency found was 14%, using all classes in the sample. The method of construction employed gives the instrument considerable face validity, as discussed previously. Nevertheless, the instrument and its scoring procedure are recognized by the investigator as an important constraint.

5.2 Recommendations

One of the problems encountered in the study was that treatments were not differentiated as strongly as the investigators would have liked. Further training sessions with the study teachers, with feedback provided until all teachers could clearly differentiate between the treatments, and interteacher variation within treatments was reduced, would have been a significant improvement. Teacher variation accounted for the largest amount of the preference variance in the data analysis. This was a particularly perplexing problem for the preference instrument, since students expressed their preferences with reference to the treatment experienced.

Since preferences toward specific teacher controlling behaviours was being measured, it was not feasible to conduct this investigation by locating teachers in the field who represented the poles of the control continuum as conceptualized in the project.

A more highly controlled, laboratory type study might have

improved the internal validity of the study, particularly with respect to reducing variation in teacher control within a treatment. Such experimental settings tend to suffer from problems of external validity, or generalizability, however. The attempt to counter-balance teacher effects with the replicated design may have been more successful with a larger number of teachers and classes, but cost and other management problems would be prohibitive.

The lack of congruence between student choice of task mode and expressed preference would make an interesting subject for further investigation. Certain kinds of subjects may tend to make such decisions on pragmatic grounds rather than a philosophical basis. However, it is unlikely that students in the sample used are often given such a decision situation, hence the choice task results could be very unreliable. Given the constraints imposed by the project, it was not possible to directly test the reliability of the student's choice, but 197 of the 296 students who did both choice tasks of round one and round two remained consistent in their choice, whereas 99 changed from one mode to the other.

Finally, it would perhaps be informative to investigate further the responses to particular items on the preference scale. A factor analytic procedure might isolate subsets, if they exist, for further study. This procedure might also have been used as a means of data reduction on the bank of independent measures available to the project.

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APPENDIX A

COMPARISON OF TEACHER ACTIONS: HIGH AND LOW CONTROL

COMPARISON OF TEACHER ACTIONS

HIGH AND LOW CONTROL

Situation	Teacher Action	
	High Control	Low Control
Opening Demonstration e.g. electromagnet	- Teacher shows ordinary magnet, describes how it works, some uses, etc. - Teacher explains how electromagnet is constructed.	- Teacher shows ordinary magnet, uses magnet to try to pick up various small objects (nails, pennies, pieces of wood, etc.). Asks pupils what they know about magnets.
Initial apparatus setup	- Teacher describes explicitly how apparatus is set up (e.g. could each group build a 20 coil electromagnet)	- Teacher asks each group to set up apparatus but without explicit directions (e.g. could each group try to make an electromagnet and get it to work).
Pupil asks unsolicited question during introduction	- Teacher answers question as directly as possible or else says she does not know or that we will find out during activity.	- Teacher asks pupil what he things or asks other class members.
Pupil has answered a previous teacher question	- Teacher usually tends to say right or good (if answer is correct) but proved almost immediately to another point.	- Teacher attempts to have pupil elaborate his answer, follow pupil's idea, or asks other pupils for responses to some questions.
Pupil indicates he does not know how to do something (during group work) or asks question about procedure	- Teacher gives explicit directions	- Teacher proceeds by questioning, by bringing pupil's partner into discussion.

(Continued)

COMPARISON OF TEACHER ACTIONS

HIGH AND LOW CONTROL

Situation	Teacher Action	
	High Control	Low Control
Pupil wishes to tell teacher what he has discovered	- Teacher praises pupil and suggests next step.	- Teacher praises pupil and attempts to have him elaborate.
Pupil says he is finished a task	- Teacher explains next step or directly suggests next activity (i.e. this is what you have to do next...)	- Teacher asks for student ideas or more indirectly suggests next step (i.e. have you tried this...)
Pupil asks teacher to explain a particular phenomenon (e.g. why does the bulb get brighter with the batteries in series but not with the batteries in parallel).	- Teacher answers with explanation or with "I don't know" or "I'm not sure" or with something like "the reason for this is kind of complicated. I'm not sure we will be able to get into that."	- Teacher answers by discussing validity of result (to be sure pupil has indeed observed what he says he has) or by saying something like "is there any reason that you can think of" or "Is there any way we can investigate a question like that". Teacher might pursue the idea that "why" questions cannot be easily answered by investigating.

APPENDIX B

STUDENT PREFERENCE INSTRUMENT (SPI)

SPI

Print your name: First _____ Last _____

Read each of the statements listed below very carefully. They are all statements on how you feel about your science lessons. If you agree with the statement underline AGREE. If you disagree with the statement underline DISAGREE. You may ask for help if you do not know a word. Just raise your hand and the teacher will come to your desk.

MARK EVERY ONE

1. I would like the science lessons better if the teacher gave more directions at the beginning of the lessons	AGREE DISAGREE	1.
2. I would like the science lessons better if the teacher and class talked about the activities less at the end of the lessons	AGREE DISAGREE	2.
3. I would like the science lessons better if the teacher gave her own ideas more, rather than paying attention to what we say about the activities.	AGREE DISAGREE	3.
4. I would like the science lessons better if the teacher spent more time asking us to do things, and less time telling us to do things.	AGREE DISAGREE	4.
5. I would like the science lessons better if more time was spent on directions (like how to do things, how to behave, and so on) rather than talking about what we worked on in the activities (like batteries and bulbs, variables, data, and so on).	AGREE DISAGREE	5.
6. I would like the science lessons better if the teacher spent more time talking to groups, and less time talking to the whole class.	AGREE DISAGREE	6.
7. I would like the science lessons better if the teacher came around to groups more often to tell us if we were doing things right or wrong.	AGREE DISAGREE	7.
8. I would like the science lessons better if the teacher asked more often for groups to give out their results in class.	AGREE DISAGREE	8.

9.	I would like the science lessons better if we were reminded more often of the way the teacher wanted us to do the activities.	AGREE DISAGREE	9.
10.	I would like the science lessons better if we were not reminded so often of what the right answer was in the activities.	AGREE DISAGREE	10.
11.	I would like the science lessons better if the teacher gave me less time to answer questions she asked me, before she asked someone else or gave the answer herself.	AGREE DISAGREE	11.
12.	I would like the science lessons better if the teacher gave fewer directions at the beginning of the lesson.	AGREE DISAGREE	12.
13.	I would like the science lessons better if the teacher and class talked about the activities more at the end of the lessons	AGREE DISAGREE	13.
14.	I would like the science lesson better if the teacher paid more attention to what we had to say about the activities rather than giving her own ideas.	AGREE DISAGREE	14.
15.	I would like the science lessons better if the teacher spent more time <u>telling</u> us to do things, and less time <u>asking</u> us to do things.	AGREE DISAGREE	15.
16.	I would like the science lessons better if more time was spent talking about what we worked on in the activities (like batteries and bulbs, variables, data, and so on) rather than giving directions (like how to do things, how to behave, and so on).	AGREE DISAGREE	16.
17.	I would like the science lessons better if the teacher spent more time talking to the whole class, and less time talking to groups.	AGREE DISAGREE	17.
18.	I would like the science lessons better if the teacher came around to groups less often to tell us if we were doing things right or wrong	AGREE DISAGREE	18.

19. I would like the science lessons better if the teacher asked less often for groups to give out their results in class. AGREE DISAGREE 19.

20. I would like the science lessons better if we were not reminded so often of the way the teacher wanted us to do the activities. AGREE DISAGREE 20.

21. I would like the science lessons better if we were reminded more often of what the right answer was in the activities. AGREE DISAGREE 21.

22. I would like the science lessons better if the teacher gave me more time to answer questions she asked me, before she asked someone else or gave the answers herself. AGREE DISAGREE 22.

DID YOU UNDERLINE ONE CHOICE FOR EVERY STATEMENT? CHECK BACK AND SEE.

APPENDIX C

CHOICE TASKS

APPENDIX C1

Choice Task: Directions for Teachers (Round 1)

In this procedure we are trying to measure student preference for the high or low control treatments.

This measure is to be incorporated into the regular classroom activity.

1. Timing:

At the beginning of the class immediately following activity 1 of the Mechanics Unit.

At this time the students SHOULD KNOW:

a. how to set up a pendulum.

b. that length, weight, and angle are some variables that could affect the period of a pendulum.

c. how to time the swings of a pendulum, meaning of "period" of pendulum

**** Teachers should avoid telling students how to control these variables in experimenting with the relationships between length, weight and period of the pendulum.

2. Materials:

per student pair: popsicle stick, string, paper clips, washers, tape, access to timer with a second hand.

per student: An index card on which to write his name and indicate his choice.

Instruction Sheets: there are two kinds (see below). Each pair of students gets one sheet depending on its choice. Take 20 of each to be sure you have enough.

3. Procedure:

a. ensure that the students are in their normal groups.

b. pass out index cards, and have students mark on it their FULL names.

c. introduction: "In today's lesson we will experiment to see HOW the period of a pendulum depends on the length of the pendulum string and the weight of the pendulum.

Each one of you can choose between two ways to do this. Think of the one You would LIKE or ENJOY doing. Think for yourself, since you are the only one who really knows what you like doing."

d. explain choices:

Teacher explains: "In the first choice you get the equipment you need, AND a sheet of step-by-step directions you must follow to do the experiment."

Teacher writes on board 1. <u>teacher gives step by step directions to follow</u>

Teacher explains: "In the second choice you get the equipment you need, BUT you follow directions which you must think of on your own to do the experiment."

Teacher writes on board 2. <u>you follow directions you think of on your own</u>

e. ask the students to think for a moment, and <u>SECRETLY</u> mark a 1 or 2 on their index card to indicate their choice. Have them choose only one.

f. collect the cards, and put them in a labelled envelope.

g. Teacher: "Perhaps your usual partner chose the one you did not. This is quite all right. We will just switch partners for this activity only."

h. assignment to groups:
   1. ask all those who chose "1" to raise hands.
   2. if both usual partners chose "1" ask them to lower hands.
   3. if any hands remain up, pair off these students. make a group of 3 if number is odd.
   4. pair off the "2's" left by themselves.
   5. Ask all the "1" groups to move to one side, (area, etc.) and "2" groups to go to the other.

i. make sure each group has the right sheet, depending on its choice.

j. make sure each group has equipment.

k. treat students in "1" groups high control; those in "2" groups, low control

l. let them work for 15-20 minutes (this may take you to end of period)

m. take over and proceed as you would normally..incorporating what the students did on this activity into your discussion, etc.

n. Give index cards to Rosetta at earliest convenience.

APPENDIX C1

Choice Task: Directions for Teachers (Round 2)

In this procedure we are trying to measure student preference for the high or low control treatments.

This measure is to be incorporated into the regular classroom activity.

1. Timing

   At the beginning of the class immediately following activity 7

   At this time the students SHOULD KNOW:

   a. How to make a working electromagnet

   b. that the number of batteries, number of coils, and coil spacing are variables that affect electromagnet strength

   c. How to measure the strength of an electromagnet

**** Teachers should avoid telling students how to control these variables in experimenting with the relationships between magnet strength and number of coils or batteries.

2. Materials

   *per student pair: 1 nail, 1 length of wire (6 ft.), 3 batteries, 1 battery holder, paper clips (several)

   *A suggestion to avoid confusion is to provide these materials beforehand in plastic baggies.

   per student: An index card on which to write his name and indicate his choice.

   Instruction sheets: there are two kinds (see below). Each pair of students gets one sheet depending on its choice. Take 20 of each to be sure you have enough.

3. Procedure

   a. ensure that the students are in their normal groups.

b. pass out index cards, and have students mark on it their FULL names.

c. introduction: "In today's lesson we will experiment to see HOW the strength of an electromagnet depends on the number of batteries used and the number of coils of wire on the nail.

Each one of you can choose between Two ways to do this. Think of the one YOU would LIKE or ENJOY doing. Think for yourself, since you are the only one who really knows what you like doing."

d. explain choices:

Teacher explains: "In the first choice you get the equipment you need, AND a sheet of step-by-step directions you must follow to do the experiment."

Teacher writes on board: 1. <u>teacher gives step by step directions to follow</u>

Teacher explains: "In the second choice you get the equipment you need, BUT you follow directions which you must think of on your own to do the experiment."

Teacher writes on board: 2. <u>you follow directions you think of on your own</u>

e. ask the students to think for a moment, and <u>SECRETLY</u> mark a 1 or 2 on their index card to indicate their choice. Have them choose only one.

f. collect the cards, and put them in a labelled envelope.

g. Teacher: "Perhaps your usual partner chose the one you did not. This is quite all right. We will just switch partners for this activity only."

h. assignment to groups:
   1. ask all those who chose "1" to raise hands.
   2. If both usual partners chose "1" ask them to lower hands.
   3. if any hands remain up, pair off these students. make a group of 3 if number is odd.
   4. pair off the "2's" left by themselves.
   5. Ask all the "1" groups to move to one side, (area, etc.) and "2" groups to go to the other.

i. make sure each group has the right sheet, depending on its choice.

j. make sure each group has equipment.

k. treat students in "1" groups high control; those in "2" groups, low control

l. let them work for 15-20 minutes (this may take you to end of period)

m. take over and proceed as you would normally..incorporating what the students did on this activity into your discussion, etc.

n. Give index cards to Rosetta at earliest convenience.

APPENDIX C2

CHOICE 1 (Round 1)

Follow these instructions carefully.

You are going to look at how the period of a pendulum depends on

a. the length of the pendulum string

AND b. the weight of the pendulum

a. Put 1 washer on your pendulum. Keep 1 washer on the pendulum while you are finding out how the period of the pendulum changes with the length of the pendulum string.

Make the measurements to fit in this table:

length of pendulum string (centimetres)	Period of pendulum (time for 5 swings)
10	
20	
30	
40	
50	

b. Use a length of 50 centimetres for this part. Keep this the same while you are finding out how the period of the pendulum is related to the weight of the pendulum.

Make the measurements to fill in this table:

Weight of pendulum (number of washers)	Period of pendulum (time for 5 swings)
1	
2	
3	
4	
5	

Write down how the period of a pendulum depends on the length of the pendulum string: _____

_____

Write down how the period of a pendulum depends on the weight of the pendulum: _____

_____

CHOICE 2 (Round 1)

You are going to look at how the period of a pendulum depends on

a. the length of the pendulum string

b. the weight of the pendulum

Make up your own directions and follow them.

Keep your measurements on this paper.

QUESTIONS:

1. How does the period of a pendulum depend on the length of the pendulum string?

2. How does the period of a pendulum depend on the weight of the pendulum?

APPENDIX C3

CHOICE 2 (Round 2)

Follow these instructions carefully.

You are going to look at how the strength of an electromagnet depends on

a. the number of batteries in series
AND
b. the number of turns of wire

a. Wind 20 turns of wire on the nail. Keep this the same while you are finding out how the number of batteries changes the strength of the electromagnet.

Make the measurements to fill in this table:

number of batteries in series	strength of magnet (number of clips picked up)
1	
2	
3	
4	

b. Use 2 batteries for your magnet in this part. Keep this the same while you are finding out how the number of turns changes the strength of the electromagnet.

Make the measurements to fill in this table:

number of turns on nail	strength of magnet (number of clips picked up)
10	
20	
30	
40	

Write down how the strength of an electromagnet depends on the number of batteries: _____

Write down how the strength of an electromagnet depends on the number of turns: _____

CHOICE 2 (Round 2)

You are going to look at how the strength of an electromagnet depends on

a. the number of batteries in series

AND b. the number of turns of wire

Make up your own directions and follow them.

Keep your measurements on this paper.

QUESTIONS:

1. How does the strength of an electromagnet depend on the number of batteries?

2. How does the strength of an electromagnet depend on the number of turns?

APPENDIX D

TESTING INSTRUCTIONS FOR TEACHERS

APPENDIX D

Directions for Teachers

1. Give questionaires at beginning of class.
2. Make sure students fill in their full names, i.e. not "George S." but "George Smith".
3. Emphasize that this is not a test, but needs to be done carefully just the same. Their papers are not shown to anyone at the school only the research staff at the university will see them - still ask them to read the choices and answer honestly. Don't allow talking, etc. while they are working on the questionaires.
4. Go over the directions printed on the questionaire. Clear up most questions at this stage. Tell students not to be shy about asking the meaning of words, etc. while doing the paper.
   There is no time limit; allow all students time to finish.
5. Please fill in identifying information on the envelope provided for completed forms (YOUR name, school, date, class, etc.). Pass them along to Rosetta at your earliest convenience.

* Students often ask "Why are we doing this?". You can answer by saying we are interested in finding out how and what students their age think, so we can 'teach them better'. Elaborate answers will probably just provoke more questions.
Also, we must know their names to keep our information straight, even though we are not interested in any one particular student's responses.

APPENDIX E

OTHER INSTRUMENTS DEVELOPED OR MODIFIED FOR USE IN THE STUDY

APPENDIX E1

The IAR Scale NAME: _____

In the following questions, pick the answer that best describes what happens to you or how you feel. There are no right or wrong answers. Your answers will not be given to anyone at your school. You may ask for help if you don't know a word. Just raise your hand and the teacher will come to your desk.

1. If a teacher passes you to the next grade, would it probably be

_____ a. because she liked you, or
_____ b. because of the work you did?

2. When you do well on a test at school, is it more likely to be

_____ a. because you studied for it, or
_____ b. because the test was especially easy?

3. When you have trouble understanding something in school, is it usually

_____ a. because the teacher didn't explain it clearly, or
_____ b. because you didn't listen carefully?

4. When you read a story and can't remember much of it, is it usually

_____ a. because the story wasn't well written, or
_____ b. because you weren't interested in the story?

5. Suppose your parents say you are doing well in school. Is this likely to happen

_____ a. because your school work is good, or
_____ b. because they are in a good mood?

6. Suppose you did better than usual in a subject at school. Would it probably happen

_____ a. because you tried harder, or
_____ b. because someone helped you?

7. When you lose at a game of cards or checkers, does it usually happen

_____ a. because the other player is good at the game, or
_____ b. because you don't play well?

8. Suppose a person doesn't think you are very bright or clever

_____ a. can you make him change his mind if you try to, or
_____ b. are there some people who will think you're not very bright no matter what you do?

9. If you solve a puzzle quickly, is it

_____ a. because it wasn't a very hard puzzle, or
_____ b. because you worked on it carefully?

10. If a boy or girl tells you that you are dumb, is it more likely that they say that

_____ a. because they are mad at you, or
_____ b. because what you did really wasn't very bright?

11. Suppose you study to become a teacher, scientist, or doctor and you fail. Do you think this would happen

_____ a. because you didn't work hard enough, or
_____ b. because you needed some help, and other people didn't give it to you?

12. When you learn something quickly in school, is it usually

_____ a. because you paid close attention, or
_____ b. because the teacher explained it clearly?

13. If a teacher says to you, "Your work is fine," is it

_____ a. Something teachers usually say to encourage pupils, or
_____ b. because you did a good job?

14. When you find it hard to work arithmetic or math problems at school, is it

_____ a. because you didn't study well enough before you tried them, or
_____ b. because the teacher gave problems that were too hard?

15. When you forget something you heard in class, is it

_____ a. because the teacher didn't explain it very well, or
_____ b. because you didn't try very hard to remember?

16. Suppose you weren't sure about the answer to a question your teacher asked you, but your answer turned out to be right. Is it likely to happen

_____ a. because she wasn't as particular as usual, or
_____ b. because you gave the best answer you could think of?

17. When you read a story and remember most of it, is it usually

_____ a. because you were interested in the story, or
_____ b. because the story was well written?

18. If your parents tell you you're acting silly and not thinking clearly, is it more likely to be

_____ a. because of something you did, or
_____ b. because they happen to be feeling cranky?

19. When you don t do well on a test at school, is it

_____ a. because the test was especially hard, or
_____ b. because you didn't study for it?

20. When you win at a game of cards or checkers, does it happen

_____ a. because you play real well, or
_____ b. because the other person doesn't play weel?

21. If people think you're bright or clever, is it

_____ a. because they happen to like you, or
_____ b. because you usually act that way?

22. If a teacher didn't pass you to the next grade, would it probably be

_____ a. because she "had it in for you," or
b. because your school work wasn't good enough?

23. Suppose you don't do as well as usual in a subject at school. Would this probably happen

_____ a. because you weren't as careful as usual, or
b. because somebody bothered you and kept you from working?

24. If a boy or girl tells you that you are bright, is it usually

_____ a. because you thought up a good idea, or
_____ b. because they like you?

25. Suppose you became a famous teacher, scientist or doctor. Do you think this would happen

_____ a. because other people helped you when you needed it, or
b. because you worked very hard?

26. Suppose your parents say you aren't doing well in your school work. Is this likely to happen more

_____ a. because your work isn't very good, or
_____ b. because they are feeling cranky?

27. Suppose you are showing a friend how to play a game and he has trouble with it. Would that happen

_____ a. because he wasn't able to understand how to play, or
_____ b. because you couldn't explain it well?

28. When you find it easy to work arithmetic or math problems, at school, is it usually

_____ a. because the teacher gave you especially easy problems, or
_____ b. because you studied your book well before you tried them?

29. When you remember something you heard in class, is it usually

_____ a. because you tried hard to remember, or
_____ b. because the teacher explained it well?

30. If you can't work a puzzle, is it more likely to happen

_____ a. because you are not especially good at working puzzles, or
_____ b. because the instructions weren't written clearly enough?

31. If your parents tell you that you are bright or clever, is it more likely

_____ a. because they are feeling good, or
b. because of something you did?

32. Suppose you are explaining how to play a game to a friend and he learns quickly. Would that happen more often

_____ a. because you explained it well, or
b. because he was able to understand it?

33. Suppose you're not sure about the answer to a question your teacher asks you and the answer you give turns out to be wrong. Is it likely to happen

_____ a. because she was more particular than usual, or
_____ b. because you answered too quickly?

34. If a teacher says to you, "Try to do better," would it be

_____ a. because this is something she might say to get pupils to try harder, or
_____ b. because your work wasn't as good as usual?

APPENDIX E2, E3

ATSCH & ATSCI

SEMANTIC DIFFERENTIAL

INSTRUCTIONS

Name: _____

On the next two pages are some words which can describe how you feel about YOUR SCHOOL and SCIENCE.

There are four blocks between each pair of words.

Put an X in the block which best describes how you feel.

Here is an example.

Think about how you feel about YOUR SCHOOL.

GOOD BAD

If you feel your school is really good, mark an X in the block closest to GOOD, like this:

GOOD [X] [ ] [ ] [ ] BAD

If you feel your school is really bad, mark an X in the block closest to BAD, like this:

GOOD [ ] [ ] [ ] [X] BAD

If you feel your school is more good than bad, mark an X in the second block from GOOD, like this:

GOOD [ ] [X] [ ] [ ] BAD

If you feel your school is more bad than good, mark an X in the second block from BAD, like this:

GOOD [ ] [ ] [X] [ ] BAD

YOUR SCHOOL

Think about how you feel about YOUR SCHOOL.

Mark an X in the block which best describes how you feel about YOUR SCHOOL

COLUMN A	MOSTLY A	MORE A THAN B	MORE B THAN A	MOSTLY B	COLUMN B
HAPPY					SAD
UNFAIR					FAIR
DULL					EXCITING
USEFUL					USELESS
CONFUSING					CLEAR
EASY					DIFFICULT
PLEASANT					UNPLEASANT
INTERESTING					BORING
AWFUL					NICE
GOOD					BAD

SCIENCE

Think about how you feel about SCIENCE.

Mark an X in the block which best describes how you feel about SCIENCE.

COLUMN A	MOSTLY A	MORE A THAN B	MORE B THAN A	MOSTLY B	COLUMN B
USEFUL	☐	☐	☐	☐	USELESS
FAIR	☐	☐	☐	☐	UNFAIR
EXCITING	☐	☐	☐	☐	DULL
DIFFICULT	☐	☐	☐	☐	EASY
AWFUL	☐	☐	☐	☐	NICE
CONFUSING	☐	☐	☐	☐	CLEAR
GOOD	☐	☐	☐	☐	BAD
UNPLEASANT	☐	☐	☐	☐	PLEASANT
HAPPY	☐	☐	☐	☐	SAD
BORING	☐	☐	☐	☐	INTERESTING

APPENDIX E4

THE WAY I FEEL ABOUT MYSELF

Print your name: First _____
Last _____

For each question, draw a circle around the letter in front of the best answer for YOU.
There are no right or wrong answers.
Circle just one letter in each question.

1. How well do you think you can do in school compared with your close friends?

   a. I am the best

   b. I can do better than most of them

   c. I am about in the middle

   d. I cannot do as well as most of them

   e. All of them can do better than I can

2. How well do you think you can do in school compared with the others in your class:

   a. I am one of the best

   b. I can do better than most others

   c. I am about in the middle

   d. I cannot do as well as most others

   e. Most of them can do better than I can

3. Suppose you were in high school.
   How well do you think you would do in your class?

   a. I would be one of the best

   b. I would do better than most others

   c. I would be about in the middle

   d. I would not do as well as most others

   3. Most of them would do better than I would

4. Forget how others describe your work. How would you describe your own work?

   a. My work is excellent

   b. My work is good

   c. My work is average

   d. My work is below average

   e. My work is much below average

5. Suppose you had to write a test on all you have learned so far in school. How well do you think you would do compared with the others in your class?

   a. I would be one of the best

   b. I would do better than most others

   c. I would be about in the middle

   d. I would not do as well as most others

   3. Most of them would do better than I would

6. Suppose you started new school work which was much more difficult than your usual school work. How much trouble do you think you would have with this new work?

   a. I would have no trouble at all

   b. I would have just a little trouble

   c. I would have a fair amount of trouble

   d. I would have a lot of trouble

   e. I would not be able to do the work at all.

PLEASE CHECK TO SEE THAT YOU HAVE ANSWERED ALL THE QUESTIONS.

APPENDIX E5

YEX

Print your name: First _____
Last _____

Place an X in the box if you studied science in that grade:

GRADE: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Total number of boxes marked ..... ☐

TEX

Place an X in the box beside the sentence which you think best describes your science classes:

1. We spent most of the time listening to the science teacher read the book to us ..... ☐

2. We spent most of the time discussing the science book with our teacher ..... ☐

3. We spent most of the time watching the teacher do science activities in front of the class ..... ☐

4. We spent most of our time doing science activities ..... ☐

APPENDIX E6

THE DEPENDENCE PRONENESS SCALE

Print Your Name: First---------- Last ----------

Read each of the statements listed below very carefully. If you agree with the statement underline AGREE. If you disagree with the statement underline DISAGREE. Some statements will not have the words just the way you want them, but mark every one the best you can. You may ask for help if you don't know a word. Just raise your hand and the teacher will come to your desk. Do not work long at each statement. Mark it and go right on to the next one. MARK EVERY ONE.

1. I hesitate to ask for help from others------- AGREE : DISAGREE
2. I like to do things with my family ------- AGREE : DISAGREE
3. It's fun to try out ideas that others think are crazy. ------- AGREE : DISAGREE
4. I enjoy working with students who get good marks ------- AGREE : DISAGREE
5. Students should be allowed to help one another with school work. ------- AGREE : DISAGREE
6. I don't need my friends' encouragement when I fail at something. ------- AGREE : DISAGREE
7. I never argue with my parents. ------- AGREE : DISAGREE
8. My parents usually have to ask me twice to do something. ------- AGREE : DISAGREE
9. I don't like my friends to make a fuss over me when I'm sick. ------- AGREE : DISAGREE
10. I seldom do "little extra things" at home just to please my parents. ------- AGREE : DISAGREE
11. I want my friends to leave me alone when I am sad. ------- AGREE : DISAGREE
12. I often disagree with my parents. ------- AGREE : DISAGREE

13. I never do anything at home until I find out if it's okay. ------- AGREE : DISAGREE

14. What others think of me does not bother me. ------- AGREE : DISAGREE

15. Working in groups is a waste of time. ------- AGREE : DISAGREE

16. I often disagree with what the class decides to do ------- AGREE : DISAGREE

17. You should always check to see if your parents approve of your friends ------- AGREE : DISAGREE

18. A good friend will never disagree with you. ------- AGREE : DISAGREE

19. I enjoy studying about things that my parents don't like. ------- AGREE : DISAGREE

20. I usually don't do something I want to do when others think that it isn't worth doing. ------- AGREE : DISAGREE

21. I owe my greatest debt to my family. ------- AGREE : DISAGREE

22. I don't like to show my friends how much I like them. ------- AGREE : DISAGREE

23. I like to make my own decisions. ------- AGREE : DISAGREE

24. My parents make unreasonable rules. ------- AGREE : DISAGREE

25. Rules are made to be broken. ------- AGREE : DISAGREE

26. I would rather be left alone when I am in trouble. ------- AGREE : DISAGREE

27. I would never tell on a student who has done something wrong. ------- AGREE : DISAGREE

28. It annoys me when my friends tell me their troubles. ------- AGREE : DISAGREE

29. I don't like lending things to my friends. ------- AGREE : DISAGREE

30. I like people who ignore the feelings of others. ------- AGREE : DISAGREE

31. I don't care if I take home a good report card. ------- AGREE : DISAGREE

32.	I often seem to do things my parents don't like	-------	AGREE : DISAGREE
33.	My parents treat me more like a child than they should.	-------	AGREE : DISAGREE
34.	I don't care if other students say mice things about me.	-------	AGREE : DISAGREE
35.	I sometimes break rules if it makes my friends like me.	-------	AGREE : DISAGREE
36.	I like to criticize people who are in charge.	-------	AGREE : DISAGREE
37.	I try never to disobey my parents.	-------	AGREE : DISAGREE
38.	I feel better avoiding a fight than trying to have my own way.	-------	AGREE : DISAGREE
39.	I like to follow instructions and to do what is expected of me.	-------	AGREE : DISAGREE
40.	My family does not like what I plan to be when I finish school.	-------	AGREE : DISAGREE
41.	I often disagree with what the teacher says.	-------	AGREE : DISAGREE
42.	In class it is best to go along with the majority even when you disagree.	-------	AGREE : DISAGREE
43.	I don't care if others are interested in the same things I am.	-------	AGREE : DISAGREE
44.	It is not always best to have the majority make the decision.	-------	AGREE : DISAGREE
45.	The playground is a poor place to really get to know your friends	-------	AGREE : DISAGREE

APPENDIX E7

What You Do and What You Think

E Scale

Print Your Name: First_____ Last_____

Read each statement and mark an X on the side that fits you better. Some questions will not have the words just the way you want them but mark every one the best you can. You may ask for help if you don't know a word. Just raise your hand and the teacher will come to your desk. Look at both boxes for each question, but pick just one of them for your answer.

1.	Does your teacher think you are good at sitting still	☐	or	☐ that you run around too much
2.	Would you rather hunt birds	☐	or	☐ draw pictures of birds
3.	Would you rather talk with your teacher	☐	or	☐ talk with a good friend
4.	Would you like to have bears here now	☐	or	☐ to hear stories about bears
5.	Is mother's way of doing things always better	☐	or	☐ is your own new way sometimes better
6.	Would you rather be a school teacher	☐	or	☐ a great hunter
7.	On a playground do you make a lot of noise	☐	or	☐ play quietly, without so much noise
8.	Would you rather write a book	☐	or	☐ be the main actor in a play
9.	When you get a new game as a present, do you like to try it first yourself	☐	or	☐ have someone show you how to play it.
10.	If teacher scolded you badly, would you cry when you told your mother	☐	or	☐ just laugh when you told her

DID YOU PUT ONE MARK DOWN FOR EVERY STATEMENT? CHECK BACK AND SEE.

APPENDIX F

OBJECTIVES AND ACTIVITIES CROSS REFERENCE CHART FOR THE THREE STUDY UNITS

OBJECTIVES AND ACTIVITIES
(measuring)

Unit

Objective	Batteries & Bulbs	Mechanics	Human Reactions
I - Problems of estimation	Bulb brightness		
II - Use of arbitrary units	Strength of electromagnet	- Weighing objects using balance	
III - Metric units			Length of optical illusion lines
IV - Subunits - Conversion		- Weighing objects using balance	
V - Instruments	Brightness meter	- Balances & rubber bands	
VI - Errors - averaging	Strength of electromagnet	Pendulum timing	Individual differences in learning and forgetting rate.
VII - judgments on precision	Effect of battery condition on brightness	Rubber band Stretching	Change of pulse rate during counting.

OBJECTIVES AND ACTIVITIES

Controlling variables

Objective	Batteries & Bulbs	Mechanics	Human Reactions
I - Identifying relevant variables	Variables influencing bulb brightness		Variables influencing pulse rate
	Variables influencing strength of electromagnet		Variables influencing rate of learning and forgetting.
II - Identifying constant and manipulated variables	Turns of electromagnet and no. of batteries manipulated, type of core, type of wire constant	Selection of cylinders to attain a single manipulated variable	Manipulate learning time, hold length of list constant.
III - Identifying responding variables	- bulb brightness - electromagnet strength - rate of change of electromagnet strength } define operationally	Relative time of rolling	Interval for recall
		Time for 1 swing of pendulum	Length of m/l illusion when perceived lengths the same
		Length of Rubber Band Scale	
IV - Identifying variables that effect the responding variable	Time of day, weather temperature, etc. compared to no. of batteries, turns, etc.	Pendulum variables. preliminary check or rolling cylinder variables	Variables influencing human physiological responses
			Variables in learning

Controlling Variables (Continued)

Objective	Batteries & Bulbs	Mechanics	Human Reactions
V Identifying uncontrolled variables which exert systematic effects and those which exert random effects.	Classroom temperature, etc. compared to turn spacing, strength of batteries, etc.	Individual variation in rubber bands	Individual differences, external history (TV watching, etc.) compared to classroom conditions in learning investigation
VI Conduct of investigation with one manipulated and one responding variable with other variables constant	Brightness of bulb as a function of number of batteries or number of bulbs in ckt Strength of electromagnet as a function of no. of batteries.	Period of pendulum as a function of length. Stretch of elastic as a function of weight.	Forgetting as a function of time Pulse rate as a function of exercise

OBJECTIVES AND ACTIVITIES

Interpreting Data

Objective	Batteries & Bulbs	Mechanics	Human Reactions
I - mean, median, range	- Strength of electromagnet	- strength of rubber bands	- optical illusions
		- frictional force using rubber band.	- pulse rate
II - constructing data tables	- strength of electromagnet - Brightness of Bulbs	- Calibration of spring balance	- Pulse rate as a function of exercise
III - Constructing graphs - scaling	- Brightness of Bulbs - Strength of Electromagnet	- Calibration graph - Pendulum - Length/weight relationships in balance	- Pulse rate of function of exercise
IV - Interpolating - averaging of errors - prediction		- Stretch of rubber bands - Balance relationships - Pendulum	
V - Extrapolating -prediction -limits	- Limit of strength of electromagnet - Limit of brightness	- nonlinearity of length/time relation in pendulum - Use of very light pendulum weights	- Limits of pulse rate
VI - Statement of lawlike relationships		-Law of lever	

APPENDIX G

SUMMARY OF MEANS AND VARIANCES OF STUDY VARIABLES

Summary of means ($\bar{X}$) and variances (S^2) of study variables

Variable		class										
		1	2	3	4	5	6	7	8	9	10	Total
SES	$\bar{X}_2$	4.33	5.11	4.67	4.83	4.61	2.80	3.28	2.68	3.69	4.50	4.00
	S^2	3.17	2.62	2.73	2.35	3.87	3.27	3.31	2.22	2.68	1.82	3.47
SCONA	$\bar{X}_2$	18.21	18.49	18.79	19.10	19.94	18.95	18.81	19.56	20.14	19.72	19.17
	S^2	4.23	10.73	14.03	11.56	8.42	7.89	11.93	9.65	3.38	7.64	8.98
DPS	$\bar{X}_2$	29.11	28.83	28.63	29.23	28.80	25.00	25.74	25.89	28.87	30.74	27.94
	S^2	14.96	14.60	23.53	33.63	21.40	21.13	20.04	30.60	27.40	18.82	25.08
SUBDOM	$\bar{X}_2$	4.25	5.06	4.40	4.39	4.49	5.90	5.43	5.82	5.35	3.43	4.91
	S^2	4.65	2.34	4.31	3.06	3.85	4.40	4.83	3.88	3.57	1.98	4.19
EXTRA	$\bar{X}_2$	17.07	17.88	18.61	16.79	18.28	18.79	18.62	19.08	19.69	17.00	18.26
	S^2	15.44	9.20	7.58	21.67	13.14	7.63	14.13	9.34	7.58	8.45	11.90
NEURO	$\bar{X}_2$	15.77	15.74	15.94	13.79	12.69	14.40	15.51	12.77	12.57	13.78	14.29
	S^2	26.46	22.02	20.00	16.80	21.51	22.03	18.65	27.81	29.25	25.09	24.03
IAR	$\bar{X}_2$	25.36	25.39	24.91	22.94	24.82	22.48	25.97	22.72	25.81	26.97	24.69
	S^2	12.87	12.82	18.61	30.81	18.88	24.15	17.87	29.21	10.05	21.84	25.21
RAVEN	$\bar{X}_2$	37.18	38.31	34.54	37.81	34.74	40.31	40.31	42.21	45.00	37.17	38.90
	S^2	91.73	34.96	91.67	63.16	57.96	49.22	59.01	22.55	18.22	58.79	62.32
COMPCTB	$\bar{X}_2$	6.16	6.65	6.43	6.73	6.84	7.02	7.32	7.26	7.89	6.55	6.90
	S^2	0.95	0.86	1.04	1.05	0.96	1.28	0.93	1.18	0.45	0.50	1.15

Summary of means ($\bar{X}$) and variances (S^2) of study variables

Variable		Class 1	2	3	4	5	6	7	8	9	10	Total
GMVOC	$\bar{X}_2$	6.06	6.76	6.58	6.81	6.45	7.71	7.62	7.75	8.92	6.69	7.19
	S^2	2.79	2.98	3.33	4.70	4.02	5.99	4.97	3.97	2.79	2.26	4.39
GMCOMPR	$\bar{X}_2$	6.47	6.77	9.11	7.64	6.43	7.70	8.54	7.84	9.86	6.73	7.72
	S^2	3.85	5.68	4.79	7.64	4.89	6.54	6.41	5.18	3.19	3.03	6.42
ATSCH	$\bar{X}_2$	32.70	32.03	35.69	9.42	35.88	30.00	32.03	30.81	31.56	33.21	32.71
	S^2	42.41	18.28	11.77	2 0.37	14.74	29.14	28.35	26.56	11.97	18.24	25.13
ATSCI	$\bar{X}_2$	33.19	34.39	34.70	36.77	37.42	30.71	33.06	33.08	34.97	35.55	34.34
	S^2	22.35	16.50	27.91	11.31	8.44	15.58	18.58	20.36	10.20	11.04	19.40
YEX	$\bar{X}_2$	1.29	1.44	1.32	2.58	1.86	4.16	3.89	3.40	1.70	1.19	2.83
	S^2	0.82	0.95	0.45	2.05	1.12	1.33	1.30	1.06	0.72	0.16	2.24
PREF5	$\bar{X}_2$	22.40	23.33	22.21	21.82	22.31	20.54	20.36	24.87	19.00	20.47	21.71
	S^2	15.45	15.46	10.04	18.29	17.18	15.10	12.42	10.47	12.17	9.07	15.88
PREF6	$\bar{X}_2$	21.90	22.14	22.32	22.95	23.17	23.98	23.60	18.05	24.59	22.22	22.47
	S^2	13.71	25.19	13.37	16.77	19.39	10.37	15.61	10.77	17.14	11.19	18.02
Percent inconsistent (SPI data)		10	18	17	25	20	16	12	13	9	16	Round 1
		11	16	15	14	16	10	8	13	6	15	Round 2

APPENDIX H

INTERCORRELATIONS OF INDEPENDENT VARIABLES

Intercorrelations of independent variables

	SES	SCONA	DPS	SUBDOM	EXTRA	NEURO	IAR	RAVEN	COMPCTB	GMVOC	GMCOMPR	ATSCH	ATSCI
SES	++												
SCONA	.18	++											
DPS	-.041*	.096*	++										
SUBDOM	.14	.043*	-.44	++									
EXTRA	.15	.17	.060*	.19	++								
NEURO	-.12	-.21	-.18	-.041*	-.20	++							
IAR	-.055*	.077*	.26	-.18	.18	-.039*	++						
RAVEN	.24	.24	.010*	.19	.18	-.12	.13	++					
COMPCTB	.31	.42	.025*	.17	.25	-.15	.13	.55	++				
GMVOC	.23	.30	.034*	.13	.13	-.084*	.10	.42	.76	++			
GMCOMPR	.18	.29	.072*	.048*	.12	-.054*	.14	.41	.74	.77	++		
ATSCH	-.040*	.22	.32	-.26	.090*	-.14	.17	-.049*	-.051*	-.069*	-.050*	++	
ATSCI	-.056*	.29	.29	-.21	.099*	-.20	.11	.025*	.090*	-.009*	.046*	.53	++
YEX	-.29	.043*	-.20	.21	.088*	-.015*	-.19	.19	.19	.15	.11	-.14	-.23

*correlation not significantly different from zero at $p < .05$ level