CHAPTER IV

PROCEDURAL DETAILS

4.0 Introduction

The procedure adopted to realise the objectives set and test the hypotheses formulated, is described in this chapter. This is carried out under four main heads viz., design, sample, tools and techniques, and the experiment. From the discussions in the previous chapter; on the scope and limitations of the study, the objectives, and the hypotheses, it is clear that the present investigation aims at studying the effect of reorganising the prescribed curricular framework on the reasoning pattern of grade IX students. Also, it is indicated that this effect is studied in comparison to the natural development and the effect of the prescribed curriculum frame. The design of the study has to accommodate the above comparison, the question of the influence of pre-assessment on the development of reasoning, and the interaction of treatment and pre-assessment. The pre-assessment as well as the assessment after treatment have to be done by posing problematic situation to each student and making observations on how he goes about finding a solution to the problem. Such an assessment demands the use of planned problems or tasks and the use of

clinical interview technique. These are discussed in detail in the sections to follow.

4.1 The Design of The Study

The design should be able to accommodate the study of the following: 1) the effect of reorganising the prescribed curriculum frame on the reasoning pattern in comparison to the existing (prescribed) curriculum frame, 2) the effect of pre-assessment on the development of these reasoning patterns and 3) the interaction between the treatment and the pre-assessment. Mitzel (1982, p.627) says that 'as the complexity of the research question increases, the complexity of the design necessary to answer the question increases as well'. He continues to say that 'in some instances the researcher may suspect that the presence of pretest affected the outcome variable or that the pretest interacted with the treatment to produce different results. The issue may be examined through what is called a Solomon Four Group Design'. Campbell and Stanley (1963 and 1971) say that the Solomon Four Group Design desrvedly has higher prestige compared to other pretest - posttest designs and control and experimental group designs and represent the first explicit consideration for external validity factors. Dayton (1970, p.156) says as follows: "The Solomon Four Group Design is an experimental design especially

constructed to provide control for sensitisation efforts in personality-change experiments. The design enables one to control and measure both main and interaction effects of testing and the main effects of a composite of maturation and history". It has become the new ideal design for social scientists says Campbell (1969). Borg and Gall (1983) say that "the Solomon Four Group Design is used to achieve three purposes: 1) to assess the effect of the experimental treatment relative to the control treatment; 2) to assess the effect of a pretest; and 3) to assess the interaction between pretest and treatment conditions" (p.691). About the effect of pretest they say as follows: "The pretest might have an effect on student achievement or attitudes because it provides an opportunity to 'practice' or think about the content incorporated in the pretest. Also, the pretest might have a special effect on the experimental group students because it 'sensitises' them to study specific content incorporated in the experimental treatment. The pretest would not have this effect on the control group because, by definition, they are not exposed to the experimental treatment content" (p.692).

The design is as follows:

Group 1	R	O_1	X	O_2
Group 2	R	O_3		O_4
Group 3	R		X	O_5
Group 4	R			O_6

where R is random assignment, X is experimental treatment and O_1 to O_6 are observations. The effect of the treatment (X) can be studied in four different ways viz., 1) O_2 O_1; 2) O_2 O_4; 3) O_5 O_6 and O_5 O_3. The actual instabilities of experimentation are such that if these comparisons are in agreement, the strength of the influence is greatly increased (Campbell and Stanley, 1971 p.195). If the pretest provides a practice effect, this should result in higher post test performance by groups receiving the pretest (1 and 2), than by groups not receiving the pretest (3 and 4). If the pretest sensitizes the experimental group to study specific content, this should result in a pretest - treatment interaction. Specifically, there should be greater difference on the posttest between groups 1 and 3 than between groups 2 and 4. This is because a sensitisation effect means that the pretest facilitates the learning of the experimental group but not the control group (Borg and Gall, 1983 p.692). Disregarding the pretests, the posttest scores can be treated with a simple 2X2 analysis of variance design:

	Treatment	No Treatment
Pretested	O_2	O_4
Not Pretested	O_5	O_6

From the column means, one can estimate the main effect of the treatment, from row means, the main effect of pretesting

and from cell means, the interaction of testing with treatment.

4.1.1 Adaptations of the design for the present study

One of the assumptions of the Solomon Four Group Design is the randomisation of the subjects in the four groups. Randomisation in the present study is not carried out by pooling all the units of the sample and alloting them to the four groups; but, four clusters are taken from an institution which does not have any specific criteria for the allotment of students into each division. Also, the equivalence of the four groups is established on two external criteria viz., 1) age and 2) non verbal reasoning as measured through Raven's Standard Progressive Matrices. This is one of the adaptations of the design to the present study. This was done because the natural setting was not to be disturbed. An artificial reallocation of the units might alter the natural setting.

Another assumption of the design is that the four groups are allocated at random to Group 1, Group 2, Group 3, and Group 4 as shown in the design (given in section 4.1). In the present investigation the two experimental groups (Group 1 and Group 3, as given in the design) belong to the academic year 1981-'82 and the two control groups (Group 2 Group 4) to the year 1982-'83. Such an adaptation was done

because of two reasons. One, the non availability of four equivalent groups from one institution. The institution has to be same, to which all the four groups belong, because the physical and social setting of different schools may differ. Also, there may be slight variations in the instructional modes (of the control groups) in different institutions. Two, the possibility of interactions among the experimental and control group students which might influence the findings, especially because the treatment prolonged for one full semester (six months). Therefore, the two groups (IX A and B divisions) of the academic year 1981-'82 were treated as experimental groups (Group 1 and Group 3 of the design); and the two groups of the subsequent year as control groups (Group 2 and Group 4 of the design).

4.2 Sample of the Study

The sample of the study comprises of four groups of students of students of grade IX of an English medium school in Baroda. Two of the groups belong to the academic year 1981-'82 and the other two of the academic year 1982-'83. The distribution of students in the four groups is given in table 4.1.

A large majority of the students in the sample are Gujaratis i.e. 90.2% of the total sample. They speak Gujarati

Table 4.1

The Distribution of the Sample of the Study

Academic year	Grade & division	Boys	Girls	N	Position in the design
1981-82.	IX A	37	13	50	Group 1
1982-83.	IX A	39	13	52	Group 2
1981-82.	IX B	26	26	52	Group 3
1982-83.	IX B	30	20	50	Group 4

at home and with peers they speak either in Gujarati or Hindi. Only 6% of the students speak English at home. The parantal occupation of 124 students, out of 184 Gujarati students, is business ranging from small shops to industries. Among the non Gujarati students only two out of twenty are doing business. The above given information is based on data collected alongwith the clinical interviews discussed in detail in the coming sections. The break up of the number of students in these groups is given in table 4.2.

Table 4.2

The distribution of parantal occupation and language spoken at home in the four groups of the sample.

	N	Parantal occupation		Language spoken	
		Business	Service	English	Indian
Group 1	50	30	20	5	45
Group 2	52	31	21	1	51
Group 3	52	33	19	3	49
Group 4	50	32	18	3	47

The institutions to which these four groups of students belong does not show any bias in allotting students to different groups. That is, no special criteria is employed while allotting students to the different divisions of a grade during admissions[1]. Therefore, the allocation of units in the four groups may be taken as quasi-random allocation although, no reallocation, after pooling all the units, has been attempted. As discussed in the previous section the equality of the four groups is established on two external criteria viz., age and intelligence as measured through Ravens Standard Progressive Matrices (RPM). The age of the students was collected from the school records and the intelligence was measured using the standardised group test. One-way analysis of variance was carried on the two sets of data viz., age and intelligence (raw scores as obtained through RPM). The age and raw scores of the test alongwith the details of calculation are given in Appendix A. The summary of the analysis of variance is given in the tables 4.3 and 4.4 (Garret, 1966 Pp.280-284).

Table 4.3

Summary of Analysis of Variance on the Age of the four groups of students (sample).

Source of variance	df	Sum of squares	Mean square	F	Signif-cance
Between	3	2.75	0.91	1.28	Not sig-nificant.
Within	200	142.35	0.71		
Total	203	145.1			

Table 4.4

Summary of Analysis of Variance on the raw scores (RPM) of the four groups of students

Source of variance	df	Sum of squares	Mean square	F	Signif-icance.
Between	3	376.95	125.65	1.26	not sig-nificant.
Within	200	19938.05	99.69		
Total	203	20315.00			

The above two tables show that the two F values are not significant. Therefore, the distribution of age and intelligence of the units in the four groups are equal since the mean differences are not significant.

4.3 Tools and Techniques of data Collection

The tools used in the present study are discussed hereunder according to the nature of data obtained from them and the techniques used to collect the data. They are discussed under four sections viz., 1) clinical interview 2) observation schedule and 3) unstructured interview. The clinical interview technique is used to assess the logical reasoning of students, the observation schedule is used to describe the classroom instruction of the experimental and control groups, unstructured interview technique is used to study the bases for the interest or lack of it in the instructional process of students (especially of the experimental groups).

4.3.1 Clinical interview

Objective No. 1 of the study demands the assessment of two reasoning patterns viz., combinatorial reasoning and controlling of variables. There are three possibilities of assessing these reasoning patterns i.e., testing, pure observation and clinical interview. The merits and demerits of each of these are discussed below to highlight the meed for a clinical approach in assessing reasoning patterns.

A paper-pencil test or any other form of testing; that is to say, the method of posing questions so arranged as to satisfy the two following requirements: first, that the question and the conditions in which it is submitted remain the same for each student; second, that each answer be related to a scale or schedule which serves as a standard of comparison both qualitative and quantitative, has certain disadvantages. The disadvantages of this method are indisputable in diagnosing children individually. Firstly, it does not allow a sufficient analysis to the results. When working under the stereotyped conditions which the test method demands only rough results can be obtained, which, though interesting in practice, are too often less of use as theory, owing to the lack of context. In short, the test method has its uses, but for the present problem it tends to falsify the perspective by diverting the student from his

natural inclination. It tends to neglect the spontaneous interests and primitive reactions of the student.

The question of pure observation arises next. In the case of present research it is the observation of the spontaneous questions or reactions of students' which furnishes data of importance. The detailed study of these questions or reactions reveals the questions which is revolving in the student's mind and thus reveals his cognitive structure. But, the direct observation method has drawbacks also. It is very tedious and is unable to guarantee the quality of the results, except at the cost of their quantity (it is, in fact, impossible to observe a large number of students under similar conditions). In addition to the above drawback, the pure observation has two systematic defects. First, the student's intellectual egocentricity constitutes a serious obstacle to knowing him by pure observation unaided by questions. The student neither spontaneously seeks nor is able to communicate the whole of his thought (Piaget, 1926 chapters I & II). The second drawback to the method of pure observation is the difficulty of distinguishing a student's play from his beliefs. It is essential to go beyond the method of pure observation and without falling into the pitfalls of the test method, to take full advantage of what may be gained

from the experiment. With this in view a third method is used which claims to unite what is most expedient in the methods of test and direct observation, while avoiding their respective disadvantages: this is the method of clinical examination, used by psychiatrists as a means of diagnosis. Cowan (1978) says that the procedure adopted in a clinical interview is designed to uncover students' thinking and reasoning abilities. The correctness or incorrectness of the answers presented by the student is important as it provides the interviewer with information about the quality of the students' thought processes (Wadsworth, 1978 p.225). Wadsworth defines the clinical interview as an ongoing experimental process in which "the interviewer asks questions to a child, listens, observes, makes a hypothesis about the child's conceptual ability, and proceeds to ask more questions based on the hypothesis he has formed". The interviewer uses probing questions to get at underlying reasoning, provides conflict situations, makes counter suggestions, encourages the child to test predictions and verify answers, suggests helpful strategies, and shifts to related tasks to verify understanding (Cowan, 1978). The interview is not a fixed set of questions but rather a set of skills to be used during a dynamic exchange between teacher and student. Posner and William (1982) say that

'the clinical interview has an information - gathering function. Its chief goal is to ascertain the nature and extent of an individual's knowledge about a particular domain by identifying the relevant conceptions he or she holds and the perceived relationship among those conceptions. Once obtained, this information could be represented in a suitable format, such as a semantic network, which would be equivalent to a partial representation of the individual's cognitive structure. This approach was pioneered by Jean Piaget who in the 1920's developed what he termed as a "clinical method" for investigating the nature and extent of childrens' knowledge' (p.195).

The interview begins with the establishment of rapport between the interviewer and interviewee. The interviewer makes sure that the interviewee has perceived the problem as he wants him/her to, by continually asking questions on his/her understanding of the problem. That is, rather, a difficult task for the interviewer, especially when the language in which he communicates comes in the way of the way of the interviewees understanding. One way of tackling such a problem is by asking the interviewee to describe the physical details of the task presented in his/her language and use the same words which he/she uses in asking further questions during the clinical interview.

While the problem is presented to the interviewee the interviewer sets several hypotheses on the responses of the interviewee. These hypotheses are tested against the actual responses of the interviewee which are stimulated. Piaget (1960) has classified the reactions of an individual, who is being clinically being examined into five categories. They are: 1) answering at random with total disinterest on the posed problem; 2) romancing: i.e., inventing an answer which he really does not believe; 3) suggested convictions: i.e., answers based on suggestions in the questions; 4) liberated convictions: i.e., answers which comes out of the mind as though it is getting liberated and 5) spontaneous convictions: i.e., answering from a previous original reflection. Among the five types of responses, the first three do not help the interviewer much in understanding the cognitive structures of the student. The last two are best suited and the 'liberated conviction' is the best between the two, from the point of view of understanding the interviewees cognitive structures. An interviewer has to be extremely cautious and sensitive in order to properly understand the responses. The interviewer has to take the whole context of the situation into consideration before judging a reaction and not analyse the responses in isolation for its merits as to find whether the response is

'right' or 'wrong'. The advantage of this technique over others is that during the presentation of a problem it can be ensured by the interviewer that it has been conceived properly. Also, wherever clarifications, are needed on the interviewees reaction, can be sought immediately by the interviewer. This would enable the interviewer in making valid judgements on the reactions of the interviewee. The disadvantage is that it is time consuming and tedious.

In order to assess the reasoning ability of children with the above mentioned technique needs carefully planned tasks or problems to be presented to the students for them to react upon. The present study is an attempt at accelerating two reasoning patterns viz., combinatorial reasoning and controlling of variables. In order to assess each of these reasoning patterns at least two tasks may be required. The assessment using one task may be risky from a scientific point of view since it may give rise to erroneous conclusions. In order to increase the validity of the information at least two tasks would be required and a correlation of the assessment between the two tasks may indicate this. Therefore, four tasks will be required to assess the two reasoning patterns. The design of the study, as given in the earlier part of this chapter (section 4.1), clearly indicates that the observations O_1 and O_2 are made

on the same students. Similarly observations O_3 and O_4 are made on another group of students. Since, there are two sets of repeated measures parallel tasks are required. The use of parallel tasks would reduce the carry-over effect to a minimum when compared to using the same task. That is, the pre-assessment may induce students to reason in a particular way or initiate certain thought patterns in them which might influence the post-assessment. Familiarity with the tasks might also make the students perform better when they are used on a repeated assessment using the same task. Therefore, it can be concluded that four tasks each for assessing the reasoning pattern are required making a total of eight.

4.3.1.1 The tasks to assess the reasoning patterns

Inhelder and Piaget (1958) describe several tasks and clinical interviews through which these tasks are used to understand the cognitive structures of a multiple cross section of children and thus trace the stagewise evolution of cognitive structures. The purpose of using these tasks by Piaget was to study the construction of formal operational structures by children. The construction of these structures is described in three main stages viz., 1) the preoperational stage (Stage I), 2) the concrete operational stage (Stage II), and 3) the formal operational stage (Stage III). In their qualitative descriptions of these stages they divide the

latter two main stages comprising of two substages each. These substages are: 1) early concrete operational substage (II A), 2) concrete operational substage (II B), 3) early formal operational substage (III A), and 4) formal operational substage (III B). Though Piaget has used the tasks to study the construction of formal structures by adolescent children, several researchers have used these tasks for assessing the stage or substage of development of an individual child through the clinical interview technique (Renner et. al., 1976; Lawson, 1979; Dale, 1970; and Lawson 1975). Renner et. al. have developed a detailed protocol for assessing and classifying the reactions of children into the four groups or substages as discussed above. Inhelder and Piaget describe the use of about fourteen tasks of which three tasks are used in the present study. They are: 1) Combination of coloured and colourless chemical bodies, 2) Pendulum task, and 3) Falling bodies on an inclined plane. The first one is used to assess the combinatorial reasoning of students and the other two for assessing the ability to control variables.

There are several other researchers who have developed similar tasks for assessing the logical reasoning patterns. Among them a few are: 1) Lawson, (1978); 2) Lawson and Wollman (1976); 3) Brederman, (1974); and Wright, (1979). A review

of these research reports reveal that the responses to several tasks by the students are influenced by cultural factors. A selected few of these tasks when presented to a few adolescent children failed to extract 'liberated convictions' and 'spontaneous convictions'. Therefore, it was decided to develop, through continuous try outs, five other tasks. The five other tasks thus developed are: 1) Fun House Puzzle, 2) Hockey Player Puzzle, 3) Electrical Switching System, 4) Photosynthesis Puzzle and 5) Rate of growth of plants problem. Among these five tasks, task 1 'fun house puzzle'; task 4 'photosynthesis puzzle'; and task 5 'rate of growth of plants' are based on tasks developed by Walker et. al. (1979), Wright (1979), and Menon (1985) respectively. Task 2 and task 4 are developed by the investigator. Of these the first three tasks are designed to assess the level of combinatorial reasoning and the latter two are designed to assess the controlling of variables. Thus, eight tasks are used in the present study, four each for assessing combinatorial reasoning and controlling of variables. A short description of these eight tasks are given below. Detailed descriptions are given in Appendix E, alongwith the criteria for assessment.

i Fun house puzzle: The interviewee is given a plan of a three room house one connected to the other in a series

with several doors. With an active interaction a path is shown to the student through the three rooms. They are then asked to show, write or tell the total number of such possible paths.

ii Coloured chemicals: The student is presented with five colourless bottles marked 1, 2, 3, 4 and G, containing different colourless liquids. He is shown a test tube containing a colourless liquid taken from the bottles singly or in combinations and to it added 'G'. The colour changes to yellow. The child on observing this is asked to try as many times as he wants and produce the colour using spare tubes.

The above described tasks are used to assess the combinatorial reasoning of students.

iii Photosynthesis: A detailed description of an experiment to find the rate of absorbtion of carbon dioxide by different parts of plants are given to the student and asked a series of questions.

iv Pendulum: The student is supplied with threads of different length and bobs of different sizes and mass. They are asked to find out the variable which affects the period of oscillation.

The above described two tasks are used to assess the 'controlling of variables' of students.

v Hockey player puzzle: The interviewee is supplied with a card on which a hockey player is drawn. Alongwith this he is also supplied with coloured paper cuttings cut in the shape of a jersey, shots, stockings and boots. Jerseys of four different colour, shots of three different colours, stockings of two different colours and boots of two colours are supplied to the interviewee. The student is then asked to find the total number of possible combinations in which the playing gear can be worn.

vi Electrical switching system: This consists of a series of five switches numbered 1, 2, 3, 4 and the last switch marked 'M'. A combination of the switches 1, 2, 3, 4 in 'on' position and 'M' in 'on' position makes a light emitting diode glow as the circuit is complete. The interviewee is then asked to try all possible combinations of the switches in 'on' position to make the light emitting diode glow. The interviewee is encouraged to try all possible combinations even after striking one combination.

The above described two tasks are used to assess the 'combinatorial reasoning' of students.

vii Growth rate of plants: The student is supplied with data regarding the growth of six potted plants. They are asked to compare the six pots to answer a question regarding the comparative growth rate under similar conditions.

viii Falling bodies on an inclined plane: The student is supplied with an inclined plane. He is allowed to vary the angle of inclination. The interviewee is given a set of metal bobs of varying sizes and weights. The interviewee is asked to find the variable responsible for the length of bounce of the bob by performing experiments.

The above described two tasks are used to assess the 'controlling of variables' of the students.

4.3.1.2 Try out and validation of the tasks

All the eight tasks described above were tried out on twentyfour IX grade students of an English medium school in Baroda. The try out sample consisted of ten girls and fourteen boys. Their age varied from twelve years and four months to fifteen years and nine months. Their average age is thirteen years and seven months. Each student was called on to a room free from disturbances and a task was presented to him/her (interviewee) by the investigator (interviewer).

Before presenting a task the investigator (interviewer) explains the purpose of the interview. Special emphasis is given to indicate that the tasks they are going to do is not a 'test' or 'examination'. This is done to reduce the 'test anxiety' of the interviewee. Alongwith this the interviewer asks questions regarding their study habits, from whom they seek help for their academic problems, their position among the siblings, etc., to establish rapport with the interviewee. Such questions asked in an informal situation gives the interviewer an insight into his interest in the curricular activities. After establishing rapport with the interviewee a task is presented to him/her ensuring clarity at each step of presenting the task. That is, after describing the task to the interviewee, the interviewer asks the interviewee to explain it in his/her own words. This helps the interviewer in identifying the hurdles of the interviewee in understanding the given problem. Care is taken by the interviewer in subsequent explanations to the interviewee to use the same words used by the latter. Detailed observations are made on how the interviewee goes about solving the problem. An audio recorder is used to record the conservation between the interviewee and interviewer. Thus two sets of observations are made viz., the interviewer's detailed recordings on the performance of the interviewee and the audio recording of the

conversation between the interviewer and interviewee. Both these recordings are then given to three judges who agree with the theoretical framework on which these observations are made and are familiar with assessing the reasoning of children using similar tasks, the invesigator being one among the three judges. The three judges were requested to assess the level of reasoning of each student. Directions were given to the three judges for assessing the reasoning patterns. The directions include the criteria for assessing the logical reasoning i.e., the reasoning patterns into four categories viz., early concrete (II A), concrete operational and showing signs of transition from concrete to formal (II B), early formal operational (III A), and formal operational (III B). The criteria were developed on the same lines as given in the protocol designed by Renner et. al. (1976). The criteria for assessment is given with each task in Appendix B.

The ratings of the three judges on the reasoning patterns (in all the eight tasks) of the twentyfour students are given in Appendix C. On a single task there can be thirtysix possible ways of disagreements among the ratings of the three judges on one student. Since there are twenty four students and eight tasks the total possible disagreements are: 36 X 8 X 24 = 6912. Out of these many possible disagreements among the judges, they have disagreed only

forty times (See Appendix C), thus making only 0.57% of the total possible disagreements. This shows the high reliability of the assessment procedure. It may also be noted from Appendix C that out of forty disagreements: there is not even a single case where the three judges have assessed a student's reasoning into three different categories. An example of such a pattern of assessment is as follows: judge A assesses a student's reasoning on a given task as II A; judge B as II B and judge S as III A. Another observation that can be made on the assessment is that the difference between the assessment of two judges on a given task and student is only of one degree. That is, the disagreement is only between two adjacent categories and not between far away ones. Out of the forty disagreements, thirty four are between the categories II A and II B and six between the categories II B and III A. All these indicate the high reliability of the procedure adopted to assess the reasoning patterns using the clinical interview technique with the aid of the tasks developed.

4.3.1.3 Relationship among the tasks assessing similar reasoning patterns

To establish the relationship among tasks assessing similar reasoning patterns, viz., combinatorial reasoning and controlling of variables, the judgements of one among the three judges is pooled together (See Appendix C).

There are four tasks used to assess each reasoning pattern. For assessing the combinatorial reasoning of students the tasks used are: fun house puzzle, coloured chemicals, hockey player puzzle and electrical switching system (Refer section 4.3.1.1). The data, from Appendix C, show that judge II (Marked 'A' in Appendix C) disagrees only, ten times out of the possible one thousand one hundred and fifty two patterns of disagreements. A total agreement of judge II on the for tasks would be one among the four possibilities viz., II A, II A, II A and II A; II B, II B, II B and II B; III A, III A, III A, and III A; and III B, III B, III B and III B. There are forty eight possible disagreements on the reasoning patterns of each student. Two examples of such disagreements are: 1) II A, II A, II A and II B; and 2) II A, II B, III A and III B. The disagreements of one judge II form only 0.86% of the total possible disagreements, i.e., 16 X 100 / 1152. This is an indicator of the relationship among the four tasks to assess the combinatorial reasoning of students.

A similar analysis on the four tasks to assess 'controlling of variables' show that judge II disagrees eight times out of the possible disagreements. This is only 0.69% of the total possible disagreements.

It may also be noted that the degree of disagreement is only one, i.e., between two adjuscent categories.

4.3.2 Observation schedule (SOCOPSI)

The hypotheses of the study (Chapter III section 3.10 demand a comparison of the experimental and control group 'inputs'. That is, a detailed description of the instruction process in both the control and experimental groups. In addition to such a comparison, the 'treatment' in the experimental group needs to be described to indicate how the instructional model referred in chapter III (section 3.4.2) operates in an actual classroom situation. It may be mentioned here that the instructional model is based on the same theoretical frame as the 'curriculum reorganising' (Refer chapter III section 3.4.1). It is worthwhile to not what Menon and Bhat (1984) have to say regarding the understanding of an instructional process. They say that 'understanding instruction would mean conceptualising, explaining and predicting its dynamics within a theoretical frame and also critically analysing it'. Reviewing studies involving classroom observation thay mention that the researchers do not seem to appreciate the need of explicating and clarifying their theoretical positions. Neither is there any attempt at articulating the various tenents of an implicit theory and asking meaningful questions, the answers of which would refine the theory. Probably because of the lack of a well articulated rational framework, the observational data

do not seem to be meaningfully collated into further questions and research problems'. The selection of various observation instruments appears to have been made arbitararily and not on the basis of a well articulated theoretical frame justifying its use. Menon and Bhat proposes a relatively unstructured manner, so that, the details of the classroom instructional process are not missed in the process of projecting a preconceived structure on reality. In other words, they suggest that the technique of observation should not limit the possibilities of eliciting such details from the reality. Bhat et. al (1981) have developed an observation schedule which accommodates the qualitative description of a classroom instructional process called "System of Observation of Cognitive Processes in Science Instruction" (SOCOPSI). The SOCOPSI has two major dimensions viz., the behaviour dimension and the process dimension. Details regarding the categories under each dimension, their explanations, and possible patterns of classroom interaction are given in Appendix D. Among the nine patterns described, the instruction through pattern IX would aid the cognitive development of the learners. The above statement is based on two reasons. One, this pattern of classroom interaction tends to approach the Science Instruction Model discussed in chapter III (section 3.4.2). That is, the classroom instructional pattern takes the shape of a cyclic process where; problems are generated,

solutions are hypothesised, invalid ones are rejected, valid ones are accepted, and the accepted ones are integrated into the previous knowledge structures. Two, pattern IX better accommodates the dynamism of the curriculum reorganising discussed in Chapter III (section 3.4.1). That is, the curriculum frame adapting to the cognitive needs of the learners' in a dialectical fashion.

4.3.3 Unstructured interviews

This technique of collecting data is used in the present investigation for three purposes. One, to gather data regarding the influence of peers, siblings, parents and other individuals on the curricular activities of the students interests, hobbies, etc. The objective of gathering such information is to get an insight into the students' interest, or lack of it, in the instructional activities. It may be mentioned here that active participation (in the cognitive sense of the term), is a condition for the development of cognitive structures and reasoning patterns of the learners (Refer chapter III, section 3.8). Two, to collect data regarding the planning and execution of curricular and co-curricular activities of the teacher who taught the control groups. Three, to collect data regarding the admission policy of the school authorities viz., the Principal and the Secratary of the trust which runs the

school. The interviews with the students, the teacher, the principal and the secratary of the school were carried out in informal situations like, the playground, the library, in the corridors, and the staff room of the school[2]. The information thus gathered was recorded by the investigator in the form of anecdotal records. Details of these records are not presented in the body or Appendices of this report because it is too unwieldy. The description of the sample discussed in section 4.2 is partly based on the information gathered using this technique.

The main difference between the unstructured interviews and the clinical interview is that in the former the investigator does not frame any hypothesis on the responses of the interviewee whereas in the latter the investigator (interviewer) frames a certain set of hypotheses on the responses of the interviewee and tests them against the actual responses. It is through the testing of such hypothesis or hypotheses that the investigator assesses the level of reasoning of the interviewee (Refer section 4.3.1.1).

4.4 The Experiment

What follows in this section is the procedure adopted in carrying out the experiment. This is described under four

subsections viz., pre-assessment of the reasoning patterns of students belonging to one each of the control and experimental groups, curriculum analysis of the chemistry portion of grade IX, description of the treatment of the content and the post-assessment data of all the four groups (two experimental groups and two control groups).

4.4.1 Pre-assessment

Among the four groups detailed in section 4.1 and given in table 4.1, Group 1 and 2 are pre-assessed using the four tasks from among the pool of eight tasks mentioned in section 4.3.1.1 and described in Appendix B. These observations are mentioned as O_1 and O_3 in section 4.1. Group 1 (experimental group, IX A, N = 50) was pre-assessed during the academic year 1981-'82 and Group 2 (control group IX A, N = 52) during 1982-'83. Among the four tasks used to assess the reasoning of the students, two were used to assess the 'combinatorial reasoning' and the other two to assess 'controlling of variables'. From among the pool of four tasks to assess the 'combinatorial reasoning' of students two were chosen at random for the pre-assessment using clinical interviews. The tasks chosen are 'fun house puzzle' and 'coloured chemicals'. Similarly from among the four tasks to assess the 'controlling of variables' of students two tasks are chosen at random for the pretest. The tasks thus

chosen are: 'Photosynthesis puzzle' and 'Pendulum'. The interviewer chose the interviewee from among the group at random. This was done to reduce the probability of students coming to the interview with 'prescribed answers'. Though the above measures would reduce the probability of students coming with prescriptive answers, it does not totally rule out such a possibility. The clinical interview technique has the capability of probing further into these 'prescriptive answers' and making the interviewee come out with 'liberated convictions' or 'spontaneous convictions'. This is a marked advantage of the clinical interview technique over group or individual testing, and pure observation (discussed in detail in section 4.3.1). Sample interviews for each of the eight tasks are given in Appendix E. Appendix E gives only the relevant portions of the sample interviews to highlight the mode of assessment. The sample clinical interviews are chosen in such a way as to give one sample interview from each of the eight tasks giving two examples from the four levels of assessment viz., II A, II B, III A and III B.

The assessment of reasoning of the two groups i.e., Group 1 and Group 2 in the design (Refer section 4.1) are given in the following two tables i.e., table 4.5 and table 4.6.

Table 4.5

The assessment of 'combinatorial reasoning' and 'controlling of variables' of Group 1 students (IX A, 1981-'82). N = 50

Levels of reasoning	Reasoning Patterns			
	Combinatorial reasoning		Controlling of variables	
	Task I	Task II	Task III	Task IV
II A	34	30	40	38
II B	13	18	7	11
III A	3	2	3	1
III B	0	0	0	0

Table 4.6

The assessment of 'controlling of variables' and 'combinatorial reasoning' of Group 2 students (IX A, 1982-'83). N = 52

Levels of reasoning	Reasoning Patterns			
	Combinatorial reasoning		Controlling of variables	
	Task I	Task II	Task III	Task IV
II A	38	34	41	37
II B	13	16	10	14
III A	1	2	1	1
III B	0	0	0	0

The details of the pre-assessment data are given in Appendix F. From the above two tables it is clear that the students reason at the concrete operational level. None of the students operate at the formal operational level (III B).

Only, three students out of fifty in the first group and two out of fifty two in the second group, show any sign of formal operational thinking on any one single task. All these clearly indicate that the majority of the students operate either at early concrete operational level or show signs of transition. Thus objective 1 of the present investigation (refer chapter III, section 3.9) is realised through the above procedure.

4.4.2 Analysis of the chemistry portion of the curriculum frame of grade IX

The second objective of the present study (refer chapter III, section 3.9) is to analyse the chemistry portion of the science curriculum of grade IX based on the level of reasoning manifested by the students. The discussion in the previous subsection (section 4.4.1) and the tables given there clearly indicate that almost all the students of the class operate at the concrete level of reasoning. Therefore, the analysis of the chemistry portion of the prescribed curriculum should aim at concretising the formal concepts so that the students can assimilate them. Also the analysis should aim at creating cognitive conflicts in the students so that the attempts by the students to resolve these conflicts would aid the development of their cognitive structures.

The different units in the prescribed curriculum frame are as follows: 1) Oxygen, 2) Hydrogen, 3) Nitrogen, 4) Phosphorus, 5) Carbon and organic compounds, and 6) The kinetics of chemical reactions. In these units the students are required to learn the physical and chemical properties of the elements mentioned, their preparation, industrial manufacturing process, and uses. Most of these concepts require formal reasoning on the part of the students for proper assimilation. For example, to assimilate a chemical reaction and to predict the 'product' of a reaction when the reactants are given requires propositional logic, combinatorial reasoning and controlling of variables.

Informal interviews with the students to find their background knowledge reveal that they have not developed the concept of matter as particulate. Also, they do not conserve mass which is primarily required to assimilate chemical reactions, predict products and understand the kinetics of chemical reactions.

The content points dealt in the text book are not properly sequenced and interlinked to form a structure. There are several gaps and these are to be filled in suitably to form a total structure. Dealing with the chemical elements as seperate units is a clear example of this.

Teaching them as seperate units would not aid the cognitive development, rather it may come in the way. The information thus learnt, by the students, would remain as isolated bits of information with no proper linkage. The students should be able to predict the preparation and properties of elements based on an understanding of the interrelationships of the properties of these elements.

All the above discussed points demand the restructuring of the curricular framework. The restructured curricular framework should fill in the gaps of the existing one, include all basic concepts required to build more complex ones, and should interlink all these into a wholistic structure.

Such a restructuring was done after analysing the content of grade IX. The whole content structure thus reformulated is given in Appendix G thus realising the objective 2 of the study (refer chapter III, section 3.9). It may be mentioned that a mere didactic presentation of the content matter given in Appendix G may not aid the cognitive development of the students (learners). The structure has to adapt itself to the cognitive requirements of the learners. Such an adaptation of the curriculum structure can only be manifested through a dynamic classroom interaction where; data is presented to the learner or recalled from their

repertoire of experiences, to cause cognitive dissonance or conflict in the students. Creating such a conflict, by providing data contradictory to the belief of the students, has two objectives. One, to arouse curiosity or kindle thought processes in students. Two, to initiate a classroom interaction which might lead to resolving the conflict. In a classroom of fifty and above students it is very difficult to involve all the students in the classroom interaction. At the same time it is not conducive from the cognitive development point of view - to restrict the classroom interaction to only a few students in the classroom. Reducing the discussion to a few students would impose restriction on other students from coming out with probable hypothetical solutions to the problem that has risen in the discussion. Therefore, it is necessary to accept all possible hypotheses on the problem from the students and treat them as valid ones until there are contradictions, within the hypothetical solutions or they are disproved by further analysis of data given by any member of the class or the facilitator (teacher). Detailed descriptions of sample instructional interactions are given in Appendix H to show how problems are evolved out of a classroom interaction and how the facilitator guides the interaction in verifying the variety of hypothetical solutions that arise through such discussions. Appendix H describes only two lessons, out of six, observed using

SOCOPST. It may be mentioned, regarding the tratment lessons that; though attempts at inducing cognitive conflicts are made during each lesson, it might not appeal as conflict to all students of the class. It would appeal to those who actively participate in the classroom interactions. Several such attempts may influence the quantum of participation as well as increase the number of students who participate.

4.4.3 Duration of 'treatment' and 'control'

The Group 1 and Group 3, discussed under the design of the study (see section 4.1), formed the experimental groups. Both these groups, divisions A and B of grade IX, belong to the academic year 1981-'82. The experimental treatment lasted for about six months i.e., the second semester of the academic year 1981-'82. Only the regular science periods provided in the school time-table were used for the treatment. That is, three sessions of fortyfive minutes duration per week. The total number of classes engaged in group 1 (IX A) were forty seven sessions and in group 3 (IX B) were fortyeight sessions. This was of particular interest to the investigator from the point of view of the feasibility of conducting such an experiment with the limitations of an actual classroom with all its constraints. The teacher of the experimental group (here the investigator) was available in the school on all working

days of a week to facilitate individual discussions initiated by the students with the teacher. There were eighteen such small group or individual discussions with the investigator during the period of experimentation[3] (six months). The small group discussions included two to three members at a time.

The investigator was available to the principal of the school to utilise his services when the other regular teachers of the A and B divisions were on leave. During the period of treatment there were eight such sessions with group 1 (IX A) and seven with group 3 (IX B). These sessions were utilised for discussing science related topics or any other topic of general interest of the students. The topics of discussion that came up during these sessions were on space technology, astronomy, meteriology, etc. The choice of topic was left to the students; sometimes it originated from the previous discussions conducted during regular classroom interactions. These sessions may also be seen as part of the experimental treatment, though they were all totally unplanned sessions. Though the sessions were unplanned, they contained an element of guided discovery to the problems that were being discussed. In short, the instructional mode of these sessions were similar to the regular classroom interactions.

Group 2 and group 4 (discussed in section 4.1) forms the two control groups. They are the IX grade A and B divisions of the academic year 1982-'83. The regular teacher of the school taught chemistry for fifty and fifty two sessions respectively in these classes. She had engaged eighteen and fifteen extra sessions respectively which were mainly used to revise the earlier portions or doing 'home work'. The patterns of her classroom interactions are given in Appendix I. Appendix I contains two sample lessions, out of six, of the control group teacher observed using SOCOPSI (refer section 4.3.2).

4.4.4 Post-assessment

Towards the end of the II semester of the academic year 1981-'82 the two treatment groups, i.e., IX A and B divisions were assessed. These are group 1 and group 3 of the design of the experiment and the assessments are O_2 and O_5 (refer section, 4.1). The tasks used for the assessment are from the pool of eight tasks described in Appendix B. The tasks which were not used for pre-assessment were used for post-assessment.

They are: 1) Hockey player puzzle (task V), 2) Electrical switching system (task VI), 3) Rate of growth of plants (task VII), and 4) Falling bodies on an inclined

plane (task VIII). As in the case of pre-assessment, the students were called one by one to a room free of disturbances and the tasks were presented to him to act upon. Detailed observations are made on the way the child proceeds to seek an answer. Based on these observations the interviewer assessed their level of reasoning into one of the four categories viz., 1) early concrete (II A), 2) concrete or transitional (II B), 3) early formal (III A), and 4) formal (III B).

Towards the end of II semester of the academic year 1982-'83; the two control groups, i.e., IX A and B divisions, were assessed. These two groups form the group 2 and group 4 of the design of the experiment and the assessments are O_4 and O_5 (refer section 4.1).

The data thus collected from both these sets, i.e.; O_2, O_4 and O_5, O_6 are given in Appendix J. The consolidated data are given in the tables 4.7, 4.8, 4.9 and 4.10

Table 4.7

The assessment of reasoning patterns of group 1 students, IX A 1981-'82. (O_2). N = 50.

Levels of reasoning	Reasoning patterns			
	Combinatorial reasoning		Controlling of variables	
	Task V	Task VI	Task VII	Task VIII
II A	19	17	29	30
II B	11	11	13	11
III A	17	17	7	7
III B	3	5	1	2

Table 4.8

The assessment of reasoning patterns of group 2 students, IX A 1982-'83. (O_4). N = 52.

Levels of reasoning	Reasoning patterns			
	Combinatorial reasoning		Controlling of variables	
	Task V	Task VI	TaskVII	Task VIII
II A	30	25	35	34
II B	16	20	13	14
III A	5	6	4	4
III B	1	1	0	0

Table 4.9

The assessment of reasoning patterns of group 3 students, IX B 1981-'82. (05) N = 52.

Levels of reasoning	Reasoning patterns			
	Combinatorial reasoning		Controlling of variables	
	Task V	Task VI	Task VII	Task VIII
II A	22	20	32	31
II B	5	7	9	14
III A	23	21	9	5
III B	2	4	2	2

Table 4.10

The assessment of reasoning patterns of group 4 students, IX B 1982-'83. (06) N = 50

Levels of reasoning	Reasoning patterns			
	Combinatorial reasoning		Controlling of variables	
	Task V	Task VI	Task VII	Task VIII
II A	29	31	37	37
II B	18	16	12	11
III A	3	3	1	2
III B	0	0	0	0

Further analysis and interpretation of the data presented in this chapter are given in the following chapter.

Notes

1. This information is based on an informal interview with the Principal of the school.
2. It may be noted here that such an informal interview was not conducted to all the two hundred and four units of the sample. Rather, it was restricted to three types of students viz., 1) those students who showed disinterest in the classroom interaction, 2) those who were overtly participating in the classroom instruction, and 3) those who have approached the investigator for help.
3. This information regarding the number of informal discussions initiated by the student is from the anecdotal records maintained by the investigator.

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