CHAPTER III

THE PROBLEM

3.0 Introduction

Having taken the theoretical framework discussed in Chapter I and the empirical evidences in Chapter II as a backdrop, what is presented in this chapter is the problem of the present investigation. A brief discussion on the acceleration studies conducted in India is presented to highlight the lack of field attempts at accelerating the development of cognitive structures in learners. This is followed by a discussion on the need for conducting an experiment in the actual field conditions. The field conditions are then reviewed with special reference to the Baroda city secondary schools as the present investigation is conducted in Baroda. Based on the field conditions and deriving principles from the theoretical framework and the empirical support, a plausible model for conducting an acceleration experiment, in the field conditions, is discussed. This is followed by the presentation of the title, objectives and hypotheses of the present investigation.

3.1 Acceleration Studies in India

Almost all the acceleration studies conducted in India within the Piagetian theoretical framework have made no attempt to relate the training strategies to the curriculum frame. The experimental inputs or the 'treatments' has been specially designed for the purpose, with very little or no relationship with the content structure of the grade to which these inputs have been given. A reorganisation of the curriculum frame is not attempted to develop the training strategies thus taking the experimental treatment 'away' from the real classroom. Among the studies reviewed there are three studies (Jha, 1979; Bala, 1980; and Bhattacharya, 1982) where an attempt at reorganising the curriculum experiences has been made. But, these studies were aimed at concept acceleration rather than the acceleration of logical reasoning. The feasibility of accelerating the logical reasoning of students in a classroom setting through curricular experiences is still an unanswered question in the Indian Context.

3.2 Need for Field Studies

The difficulty of integrating or adapting experimental results into the actual field has been expressed by many. Campbell and Stanley (1965) say that the direct contributions from controlled experimentation to the field conditions have been disappointing. The claims made for the rate and degree of progress which would result from experiment were exaggerated and were accompanied by an unjustified depreciation of non experimental wisdom. Finkelman (1978) says that the simplification inherent in the experimental situation often results in the focusing of an isolated, arbitrary or trivial aspect of the phenomena under study. Even if the experiment does get at basic processes these rarely occur in isolation with other processes, and it may render the experimental results of little value for understanding real-world phenomena. Yadav et. al. (1981) say that studies conducted in actual conditions would give scope for a much larger number of variables to operate resulting in a very complex interplay, and thus may bring out new patterns of relationships, different from those which emerge in controlled conditions.

The above discussion shows how the relationships one studies under strict laboratory conditions vary from field conditions and there arises a need for studying the relationship in actual field conditions. Even the field conditions in different settings vary and therefore, the results obtained from the field conditions elsewhere may not find much of a relevance in India. So, an assessment of the field conditions in India is required before formulating an acceleration experiment in the actual classroom.

3.3 Field Conditions in an Urban Classroom in India

The curriculum frame in the Indian schools is highly centralised and the schools have practically no freedom to reorganise the prescribed curriculum frame. The curriculum frame for the schools affiliated to the respective state boards of secondary education are prepared by the board in active collaboration and/or in consultation with the State Institutes of Education (S.I.E.s) and the National Council of Educational Research and Training (N.C.E.R.T.), New Delhi. The schools affiliated to the Central Board of Secondary Education (C.B.S.E.) passively receive the curriculum frame prepared by the Board in consultation with the N.C.E.R.T. The text books for different grades, which form part of the curriculum frame, are also prepared by centralised agencies like the N.C.E.R.T. and the S.I.E.s and the text book boards of different states. Mehta (1983, Pp. 35-47) discusses the state of 'nationalisation' of school text books in India. She shows that the centralised text book agencies like N.C.E.R.T. and the text book boards generally prepare only one set of text books for each grade or standard and there are very few states like Meghalaya and Tripura preparing text books with the help of private agencies. The evaluation system, which also forms an integral part of the curriculum frame, is also highly centralised (in the form of 'public examinations' conducted at the end of secondary education i.e., grade X) and the whole instruction is directed towards this 'public examination'. The above discussion indicates how the text books, examinations and the classroom instruction which forms part of the curriculum frame are designed and controlled by centralised agencies which make the framework very rigid and static. Menon et. al. (1985) make another observation regarding the school curricula - for instance the science curricula - that it is taken to be just an assemblage of information with no central theme cutting across them. It is not appreciated sufficiently that every curriculum should have an underlying theme depending upon the objectives of teaching that subject from the context. Moreover, curriculum should not be taken just as a static course outline or a text book but also as involving tested suggestions of instructional process alternatives'. Reviewing the curriculum researches conducted in India they observe that 'the limitations of the present day curriculum research in India seem to be a consequence of a highly state controlled, centralised and bureaucratic set up of Indian Education. Most professional research institutions do not seem to enjoy autonomy to try out alternative models of curricula because of the inertia offered by the school system. Moreover, there is hardly any school which is permitted to frame its own curriculum. Hence, the whole enterprise seems to have caught up in a highly inert structure'. They conclude the discussion by mentioning that what is needed in India is diverse models of curricula to suit the diverse needs.

Kapadia (1971) and Patel (1979) on analysing the science text books of the Gujarat board report that they are badly prepared. They found that students often get confused with the content matter presented in the text books because of its lack of logical organisation. Kapadia reports that the authors of the different sections of a text book in science have no co-ordination among themselves. Such a science curriculum frame and text book imposes a heavy pressure on the teacher to 'complete the course'.

The internal evaluation system in a school is centered around testing the rote memory of a student. This includes the classroom questions asked by a teacher to evaluate the effectiveness of his teaching. Kaul (1975) reports, after conducting an enquiry into the questioning behaviour of the teachers that only 8.7% of the time of classroom instruction is used by science teachers to ask questions out of which more than 87% of the questions are of recall type. Kapadia reports that the questions asked in the annual examinations (terminal examinations conducted by the schools) and other tests are very 'textual'. The questions are repeated over years and therefore students tend to predict the questions and thereby leave a bulk of the syllabus unlearnt.

Apart from the rigidity imposed by the curriculum frame there are several other constraints on the working teacher to attempt at reorganising the curriculum with a view of developing the cognitive structure of the learners'. One such constraint is the work load of a secondary school teacher. Baxi (1959) and Kapadia (1971) report that the work load of a secondary school teacher is about 20 to 22 hours of teaching per week. It is also reported that the teachers are given other work in addition to the teaching load in the form of organising various other activities of the school, like fee collection. The teacher gets hardly any time to pay individual attention to the students. Another constraint imposed on the working teacher is the faith the school authorities, students and the members of the society at large who are concerned with the education of their wards, place on the text book. A teacher who would like to reorganise the curriculum frame is compelled not to do so by these forces. A third constraint on the teacher is concerning the teacher-pupil ratio in an urban classroom. Gandhi (1968) reports that the number of students in a classroom range from thirtyfive to seventy. Such a high ratio prevents the teacher from organising activities for each individual student so that he can discover the rules and principles and thus construct his cognitive structure from his actions. Also, it may be mentioned here that very few secondary schools in India are equipped with laboratory facilities for such a large number of students to do experiments and discover the laws, principles, etc., in science (Gandhi, 1968 and Patel, 1971).

The field conditions in India seem to be markedly different from those in other countries where real classroom experiments on accelerating the logical reasoning of learners have been tried out (discussed in detail in the previous chapter). The curriculum frame is outdated and disorganised. There is a lack of a theory base in the curriculum framing. The curriculum demands a lot of hard work from the students in rote memorising the facts, principles, etc. There is hardly any provision for the students to act upon objects and ideas and discover the laws and principles of natural phenomena. The curriculum experiences are rather prescriptive and curb the students from thinking in an original manner.

3.4 Is Acceleration Possible Under These Conditiohs?

This question whether it is possible to influence the cognitive development of the learners under the field conditions described above is not answered as there is practically no empirical evidence to support it. But, studies conducted under laboratory conditions or quasi-laboratory conditions in India and elsewhere, and those field studies conducted under other conditions suggest the possibility of influencing the cognitive development of the learners. If cognitive development, which includes the development of logical reasoning and the construction of physical reality, is taken as the objective of teaching science, a thorough restructuring of the curriculum and executing it through a model of instruction which would induce cognitive conflict or dissonance in the learner might be of help.

3.4.1 Reorganising the curriculum frame.

Ausebel (1963) argues that 'any science curriculum worthy of the name must be concerned with the systematic presentation of an organised body of knowledge as an explicit end in itself'. There are many other educationists who would tend to agree with him. Such a systematic presentation of the body of knowledge may not by itself be able to produce any effect in the construction of logico-mathematical structures and concept structures by the learners. The total reorganisation of the curriculum frame may have to be done in the light of 1) the previous concept structures of the learners and 2) the logical reasoning patterns they are capable of manifesting. This manifestation depends on the logico-mathematical structure of the learners. This is one implication that can be derived from the empirical evidences discussed in the previous chapter (refer section 2.7). It becomes all the more meaningful in the Indian context because the students of a particular grade have undergone the treatment of a static and ill-prepared curriculum all through their previous years of schooling. It is ill-prepared from the point of view that any curriculum should have a theory base (Menon et. al. 1985). Menon (1985) on analysing the science curriculum of grades VIII to XII reports that such a theory base is lacking in the organisation of the science curriculum of the secondary and higher secondary stages. Looking at the problem of reorganising the curriculum frame from the theoretical framework on which the present study is based demands the assessment of the concept structures as well as the logico-mathematical structures of the learners. This can be further explained with an illustration. A curriculum frame in Chemistry, which deals with the structure and transformations of substances under stipulated conditions, demands the prior conceptual knowledge of the molecular nature of matter and their transformations can occur in certain patterns depending upon the physical conditions. If such a background knowledge is absent in the learner it has to be developed. The development of such concepts faces a serious hurdle if the learners are operating at a concrete level. The concept that matter is made of discrete particles and these particles are capable of certain transformations depending on their structure, needs formal logic to assimilate. To concrete operational learners, perhaps, the best way to approach the problem is by concretising the data from which scientists themselves arrived at these concepts. The concretised data may be presented to the learner, after assessing his concept structures, in such a way as to arouse curiosity and create certain conflicts in the mind of the learners similar to those developed in the scientists who have constructed these laws, principles and theories. The assessment of the concept structures of the learner is important because that would reveal the internal contradictions and gaps in those structures which would form a major sourse of directive for the resequencing of data. Giving a historical perspective to the resequencing of the curriculum frame may be of relevance. But tracing the history of development of a concept through time may not be required in a classroom instruction. Historically, concepts might have evolved in a detour fashion after having entertained many alternative explanations to the phenomenon concerned and taking time to eliminate the incorrect explanations pending theoretical and methodological breakthroughs. Since learning is what may be called a rediscovery of the conceptual structure of science, most of these detours could be bypassed while reorganising the curriculum frame to ensure the economy of instruction (Arunkumar et. al., 1984). Some of these detours may arise from the learner as he progressively constructs his cognitive structure. The facilitator (instructor) will have to be sensitive to accept these detours and not to 'ignore' them, and present the right type of data, from the historical development of the concept or artificially contrived ones, to make the learners realise the contradiction in those detours thereby aiding him in constructing stabler concept structures.

Another principle that can guide an attempt at reorganising the curriculum frame is that, the reorganisation should be done in consideration to the conceptual structure of the discipline. Shulman and Tamir (1973) quoting Schwab in their article on research on teaching say that 'the conceptual structure of a discipline determines what we shall seek the truth about and in what terms that truth shall be couched. The syntactical structure of a discipline is concerned with the operations that distinguish the true, the verified, and the warranted in that discipline from the unverified and unwarranted. Both these - the conceptual and the syntactical - are different in different disciplines'. Schwab clearly indicates how the conceptual structure of the discipline determines what is to be taught. From the above discussion we can conclude that a curriculum reorganisation has to be carried out in considering the following: 1) the prior concept structure of the learners', 2) the logical reasoning patterns the learners are capable of manifesting based on their logico-mathematical structures, and 3) the conceptual structure of the discipline. Such a reorganisation of the curriculum frame should make it highly flexible and dynamic. The dynamism and flexibility of the curriculum frame may be seen in terms of its adaptability to the various cognitive demands of the learners. Such a dynamic curriculum frame should make it highly flexible and dynamic. The dynamism and flexibility of the curriculum frame may be seen in terms of its adaptability to the various cognitive demands of the learners. Such a dynamic curriculum frame may be successful in inducing cognitive conflicts in the learner by resolving which he constructs stabler cognitive structures.

3.4.2 A theory based model of instruction

The dynamism of such a curriculum frame would mostly be seen in the instructional model, the model being a part of the curriculum. So, the theory on which the instructional model is based will have to be the same as that on which the curriculum frame is based. The purpose of instruction, therefore, is construction of cognitive structures in the learner isomorphous to the conceptual structure of the discipline. Though this idea seems to be more in tune with the Ausebelian subsumption theory of learning (Ausubel, 1968), it is very similar to Piaget's formulations regarding scheme of cognitive organisation which reflects his interests in the developing relations among the elements of knowledge (Shulman and Tamir, 1973). Hence, learning of science is not merely storing isolated bits of information concerning natural phenomena in memory, but progressively, constructing a wholistic, unified, and internally consistent understanding of the phenomena. For, such an evolution of wholistic structures in the learner necessitates the use of processes of scientific enquiry as a strategy. It is worthwhile, at this juncture, to note what Schwab (1962) has to say about classroom instruction as inquiry. "The phrase - the teaching of science as enquiry - is ambiguous. It means, first, a process of teaching and learning which is, itself an enquiry, 'teaching as enquiry'; second, instruction in which science is seen as a process of inquiry, 'science as enquiry'. The ambiguity is deliberate. Both these meanings are part of the idea in its complete form. The complete enquiry classroom would have two aspects. On the one hand, the student would be led to inquire into these materials. He would learn to identify their component parts, detect the relations among these parts, not the role played by each part, detect some of the strengths and weaknesses of the inquiry under study. In short, the classroom would engage in an enquiry into enquiry."

The distinction between 'science as enquiry' and 'teaching-learning as enquiry' is an important one. In the second, it may be noted that the activity in which the student participates is not scientific enquiry per se, but, the critical analysis, interpretation and evaluation of reports of scientific enquiry. Therefore, a classroom interaction cannot be an uncontrolled free enquiry. Free enquiry or science as enquiry does not seem to aid the development of cognitive structures of those learners who operate at the concrete level (refer Chapter II, section 2.5). A guided enquiry approach where the teacher acts as a facilitator and guide to the process of enquiry would be better. It may be noted here that the facilitator and guide to the process of inquiry may provide data in such a way to the learners that the problem arises from within the learners rather than the facilitator giving prescriptive problems to the learners. These prescriptive problems may not appear as problems at all to the learners. A conceptual background is prepared by the teacher (facilitator) through discussion or through the provision of a concrete experience which culminates in the identification of a problem by the learners.

The teacher consciously creates the background of the problem keeping in view the total curriculum frame and the concept to be highlighted and also the level of abstraction which the stage of cognitive development of the learners' allows. In this given background the problem gets evolved as a hurdle in the way of the learners' explaining a certain phenomena. Confronted with the problem, the next step would be to call for alternative hypothetical solutions to it. Here the teacher's role would be mainly to act as a moderator and thereby see that every member of the class participates and a hypotheses, however apparently irrelevant it might be, is taken seriously. Concomitant to this, can be the logical exercise of eliminating internally contradictory propositions. Such an exercise should be done mostly by the fellow learners (peer interaction referred to in Chapter II, section 2.6). Those hypotheses which cannot be challenged through possible observations are not taken into consideration. They may be considered metaphysical propositions and not scientific questions. The next stage is essentially aimed at testing the hypotheses formulated in the earlier stage. The first step in the testing procedure is to deduce the hypothesis into possible observational events through which it can be tested for its validity. However, for the testing per se, a formal instructional situation has a lot of constraints regarding physical resources and time. Ideally, what is desired and could be done wherever possible, is to fabricate procedures through which observations can be made regarding the validity of the hypothesis. Many a time, this may not be possible due to the nature of the hypothesis, nature of the concept, facilities required for making the necessary observations, the time it might take, etc. In such situations, there could be three other ways of putting the hypothesis to test. One is the recollection of common experiences of the learners and their proper organisation in such a way that these experiences provide evidence regarding the validity of the hypothesis. If the experiences called for are unfamiliar to the learners, the teacher may provide data derived from relevant experiments conducted by the scientists. A third way of testing would be to evolve through discussion certain observations that could be made by the learners at home or through a project/assignment involving field observations. In all the above four ways of testing what is of paramount importance is that the learners actively participate in the planning and fabrication of the testing procedures making direct observations wherever possible and interpret and formulate conclusions from observations made or data provided. Hypothetical solutions to the problem having been tested would be meaningfully integrated to the cognitive structures.

Also, these empirical evidences arouse further problems for investigation. Thus, the whole process of instruction is cyclic in nature (Arunkumar et. al., 1984).

3.5 The Effect of Curriculum Experiences on the Reasoning Patterns

The organisation of the curriculum frame on those lines discussed earlier and executing it through the cyclic model of instruction described above is likely to aid the construction of stabler cognitive structures by the learners. This would include the construction of both the concept structures (knowledge of the physical world) as well as the logico-mathematical structures. The above statements are made based on two reasons. One, the concretisation of formal concepts can be better assimilated into the cognitive structures of the concrete-operational learners. Several such assimilations of concretised data would demand the structures to undergo modifications. This need arises from within the learners. Two, the dynamic curriculum frame is capable of adapting to the cognitive needs of the learners' and inducing cognitive dissonance in them. The resolution of these cognitive conflicts would aid the construction of stabler structures.

In the intellectual development model propounded by Piaget, mental operations appear during the third stage, i.e., the concrete operational stage. Piaget (1964) says 'when learners discover the properties of their actions, they have begun to perform mental operations. An operation obviously is reversible and is an interiorised action'. An early concrete operational child may need a long term interaction with the environment to transform to the formal operational stage. Also, the early concrete operational child may not benefit out of instruction of formal concepts, though it may be presented in a concrete form, as he is not equipped with a structure that enables him to assimilate such concepts. Therefore, it may be worthwhile to attempt at influencing the cognitive development of learners when they are in a transition from concrete to formal operational stage. This is more relevant from an experimentation point of view because the time duration that can be spared for the experiment is limited. Kimball (1973) discusses the following points in answering the question whether formal operations can be induced. 'The individual that is to be introduced to the formal operations must be facile with the concrete operations; able and experienced in manipulating materials; capable of formulating generalisations; identifies variables and exhibits reversibility'. The above discussion by Kimball clearly indicates that an attempt at accelerating the reasoning patterns may be carried out with fully concrete operational learners and not with early concrete operational learners.

Most of the acceleration studies reviewed in Chapter II have been carried out with transitional learners.

3.6 A Transitional Group in the Secondary School System

Tha age range suggested by Piaget, following the data collected from Genevan children, may not be of use in identifying a transition group in Indian conditions because cross cultural studies carried out elsewhere by several researchers indicate wide variations from the Genevan norms (Chiappetta, 1970; and Dasen, 1974). In India there is no study which reports the distribution of concrete and formal operational students in the secondary school system. Vaidya (1974) indicates that more than 70% of pupils of grade X could not test hypotheses. Chand (1980) reports after studying the mental operations of 240 boys and 240 girls between the age range of 4+ and 15+, that even students of age 16 does not operate at the formal operational level. These studies do not suggest a transition group. Therefore, a bench mark data was collected from the field. The sample included students from grade VII, VIII, IX and X. The data was collected from three English medium schools in Baroda city. The 'colour chemical task' (Piaget and Inhelder, 1958 Pp.107-122) was used to probe into the reasoning pattern of the students (See Appendix B). A clinical interview technique was used to assess the logical reasoning (the clinical interview technique is discussed in detail in the next chapter on procedural details, as a discussion here is unwarranted). The results of the interviews after analysis were classified into four categories of reasoning patterns viz., concrete operational (II A); transitional (II B); early formal (III A) and formal operational (III B). The protocol developed by Renner et. al. (1976) was used for this classification. The number of pupils interviewed, the number of transitional students (II B) and the percentage of transitional students is presented in Table 3.1.

Table 3.1
The percentage of students who show signs of transition from concrete to formal reasoning

Grade	VII	VIII	IX	X
tran.	3	6	26	12
N	38	25	48	22
%	7.7	20	54.3	54.5

3.6.1 Reasoning Patterns That Differentiate Concrete and Formal Operations.

Another question that comes in alongwith the selection of a grade having students belonging to a transitional group is the one regarding the discrimination between the concrete and formal operational students from an assessment point of view. The formal reasoning is a complex structure and so its assessment is a complicated job. To describe the level of reasoning of individual students, and to assess their cognitive capabilities, the notion of reasoning pattern is more useful than the composite operational structure. Karplus (1979) says, a reasoning pattern, such as seriation, controlling variables, conservation, is an identifiable and reproducible thought process. Reasoning patterns have underlying logical and logico-mathematical operations proposed by Piaget. Some of these operations appear to be fairly easily identifiable in a student's words and actions, while others require detailed observation and analysis. By contrast, reasoning patterns are better evident when a student is confronted with a problem and in the way he goes about solving it. A few examples of reasoning patterns that occur while a student is confronted with a problem are: 1) combinatorial reasoning, 2) controlling of variables, 3) deductive reasoning, 4) proportional reasoning and 5) serial ordering. These reasoning patterns are interrelated - some of them closely while some others are relatively a little remotely. The reasoning patterns all together form the logico-mathematical structure and the closely related patterns form 'schema' within this total structure. Different schemata interact among themselves and evolve from lower states of equilibrium to higher ones (See chapter I, section

1.2.1). Some of these schema evolve to a higher level compared to others. Such differences in the levels of evolution of schema is termed as 'décalage' in the Piagetian theoretical framework. Therefore for an experimental purpose it would be better to choose closely related schema especially from an assessment point of view, to represent the total logico-mathematical structure. From the examples of reasoning patterns given above combinatorial reasoning and controlling of variables are closely related. These two reasoning patterns have been used by other researchers in attempting at developing the formal operational thought. A few among them are Kuhn and Angelev, (1975); Karplus, (1978); Woolman & Chen, (1982); and Lawson et. al., (1975). Lawson (1979) says "In Piaget's theory, formal stage reasoning manifest itself in a variety of ways. For example, the generation of all possible combinations of variables, the isolation and control of variables, and the solution of proportionality, all theoretically require formal operations. Although these abilities may appear to be unrelated, in theory they are all mediated by the development of a structural unit of an unified whole. Thus, according to theory, individuals should exhibit consistency in performance across tasks that require these operations. The evidence for this consistency, however is inconclusive" (p.67). Though Lawson mentions that the relationship among the three reasoning patterns is inconclusive, the generation of all possible combination of variables and the 'isolation' and 'control' of variables appear to be more relatively connected because 'generation' of all possible combinations is required for 'isolating' and 'controlling' variables. Therefore, the assessment of concrete and formal operations in students may be done using tasks or problems which demand the children to manifest their combinatorial reasoning (generation of all possible combinations), and to isolate and control variables in a multivariate situation. Thus, 'combinatorial reasoning' and 'controlling of variables' form a part of the 'combinatorial system', which forms a major part of the formal logic.

The discussions in the two preceeding sections indicate the choice of grade in the secondary school system for the present attempt at influencing the cognitive development and the choice of reasoning patterns in order to assess the logico-mathematical operations of the students. Summarising the discussions from sections 3.4, 3.5 and 3.6 the research question of the present study boils down to whether the reorganising of the curriculum frame as discussed earlier would aid the development of reasoning patterns of the transitional group of students under actual classroom conditions. That is, an active participation by the students on the curriculum material presented to them is required for the acceleration of the reasoning patterns. In an actual classroom there may be many students who are basically not interested in the instructional activities. These students would pose a major hurdle in seeking an answer to the above discussed research question.

3.7 Title of the Present Investigation

A STUDY OF THE EFFECT OF REORGANISING THE PRESCRIBED CURRICULAR FRAMEWORK ON THE COMBINATORIAL REASONING AND CONTROLLING OF VARIABLES OF GRADE IX STUDENTS.

3.7.1 Expansion of terms

(a) reorganising: The reorganisation of the curriculum frame is done after taking into consideration 1) the background knowledge of the learners 2) their logico-mathematical structures and 3) the conceptual structure of the discipline. As the knowledge of the physical reality and their reasoning abilities develop, the curriculum frame should get modified to suit the growing cognitive capabilities of the students. Therefore, the reorganising is dynamic and flexible in contrast to a 'reorganised' curriculum frame which would be static and rigid.

(b) curriculum frame: The curriculum frame in the present study refers to the chemistry portion of the prescribed science curriculum frame for the grade IX of the Gujarat Board of Secondary Education.

(c) combinatorial reasoning: This is a reasoning pattern manifested by a student when posed with a problem that requires the generation of all possible combinations pertinent to the solution of the problem.

(d) controlling of variables: Recognising the necessity of an experimental design that controls all variables except the one being investigated.

3.8 Scope and Limitations of the Study

The study is aimed at accelerating the logical reasoning of students with the aid of curricular experiences in a real classroom setting, with all its natural interferences. To this extent it is not a laboratory type of experimentation where the variables are controlled. The assumption here is that the students will actively participate in the classroom interaction so that their reasoning patterns develop. But, within the limited period of time that can be spared for a Ph.D. work it may not be possible to get all the individuals of a classroom motivated to take part cognitively in the interaction process. This task becomes all the more difficult when the instructor and learners are 'new' to each other. There are several other factors which contribute to making this task difficult viz., the social and economic background of the learners, their interests and aptitudes. Thus, the experiment is an attempt at accelerating the reasoning patterns of students in an actual classroom setting with not much of an effort made to control the umpteen intervening variables. The experimentation is for a short period to expect total developmental changes in the cognitive structures. Given these restrictions the study aims at finding out how far the reorganising of the curriculum frame can accelerate the logical reasoning of students in the present school set up.

3.9 Objectives of the Study

The objectives of the study can be stated as follows:

1. To assess the level of reasoning of students of grade IX in the following reasoning patterns
   (a) combinatorial reasoning and (b) controlling of variables.

2. To analyse the chemistry portion of the science curriculum of grade IX with a view to reorganising it to suit the level of reasonong of the students.

3. To study the effect of reorganising the curriculum frame on the following reasoning patterns

(a) combinatorial reasoning and (b) controlling of variables in comparison with the existing curriculum frame.

The assessment of the level of reasoning (objective No.1) demands the use of problems or tasks to be presented to the students and observing the way they go about solving it. The exposure to such problems or tasks might interfere with studying the effect of the treatment (objective No.3). Here arises the need to study the effect of the pre-assessment and its influence on the treatment. Therefore, the following two objectives are added alongwith the above three.

4. To study the effect of assessment of the reasoning patterns, (a) combinatorial reasoning and (b) controlling of variables on the development of the same reasoning patterns.

5. To study the interaction between the pre-assessment and treatment on the two reasoning patterns viz., (a) combinatorial reasoning and (b) controlling of variables.

3.10 Hypotheses of the Study

An analysis of the objectives of the study in the background of the theoretical framework and the empirical evidences and taking into consideration the field conditions in India, the following hypotheses are formulated.

1. The reorganising of the chemistry portion of the science curriculum for grade IX may positively influence the combinatorial reasoning of students when compared to those students who undergo the normal classroom teaching based on the existing curriculum frame.

2. The reorganisation of the chemistry portion of the science curriculum for grade IX may positively influence the 'controlling of variables' of students when compared to those who undergo the normal classroom teaching based on the existing curriculum frame.

The above two hypotheses have been framed in the directional form since earlier attempts show that acceleration is possible.

The objective 1 demands the assessment of the reasoning patterns of the students before attempting at reorganising the curriculum frame. This is done by posing problems to the students which demand them to manifest these different reasoning patterns. Such a pre-assessment may affect the development of these reasoning patterns. Among the studies where such a test sensitivity has been measured, Rowell and Dawson (1981) report that pretest has influenced the volume conservation of grade VIII students in a classroom acceleration experiment. But, they add that the influence of the pretest was only to a small extent. This is not convincing enough to formulate the following hypotheses in the directional form and therefore, they have been expressed in the null form.

3. There is no difference in the combinatorial reasoning of students, who have been assessed through a task or tasks which demand(s) the use of such a reasoning pattern, and those who have not been assessed through such a task or tasks.

4. There is no difference in the 'controlling of variables' of students, who have been assessed through a task or tasks which demand the use of such a reasoning pattern, and those who have not been assessed through such a task or tasks.

The above two sets of hypotheses indicate that there are two possible sources of influences on the reasoning patterns viz., the pre-assessment and the treatment. In such a situation in addition to the possible individual influences there can be a joint effect of the two influences acting together (objective No.5). This objective calls for the formulation of two more hypotheses.

5. There is no difference in the 'combinatorial reasoning' of students, who have been pre-assessed on the same reasoning pattern and who have undergone the treatment (the reorganising of the science curriculum), and who have not been pre-assessed and not undergone the treatment; and those who have not been pre-assessed and who have undergone treatment, and those who have been pre-assessed but not undergone the treatment.

6. There is no difference in the 'controlling of variables' of students, who have been pre-assessed on the same reasoning and who have undergone the treatment, and who have not been pre-assessed and not undergone the treatment; and those who have not been pre-assessed and who have undergone treatment, and those who have been pre-assessed but not undergone the treatment.

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