CHAPTER II
SURVEY OF RELATED LITERATURE AND STUDIES:

2.0.0 PROLOGUE:

The objectives of the study have been given in Chapter I. The objectives of the study were classified into different categories such as Presage-Product, Process-Process, Process-Product, and Context-Process. While reviewing the research studies with respect to expository-discovery controversy the same classification was followed. The research studies and implications of these studies for future researches have been discussed in this chapter.

Attempts have been made by the investigators to solve expository-discovery dilemma since long. But due to pervasive influence of a small book, 'The Process of Education' by Bruner, the researches in this particular controversy boosted up. Bruner put forth the idea of discovery, structure, early readiness and intuitive thinking. These ideas did not receive due attention uptill 1950, but after that, these ideas captured the field of research in the area of teaching. Bruner's thinking traces back to Plato through Hegel and Dewey. Psychologically it is influenced by Gestalt Psychologists initially and more recently by Piaget.

As Hegel recognized two centuries ago, there is always a dialectical quality to history. Every successfully advanced
thesis seems to generate its own antithesis. Curricular researches were undertaken by University of Illinois Committee on School Mathematics, Madison Project in the area of teaching of mathematics. Discovery method was the important and common factor to both the projects. The success of these projects resulted in calling forth of antagonistic position. Gagne, Ausubel, each of them has taken marked opposition to Bruner. Approaches suggested by two may be called as antithesis of discovery, 'expository'.

Ausubel stresses the need of meaningful verbal learning whereas Gagne stresses the importance of capability. Capability means ability to perform certain specific functions under specific conditions. Gagne's position grows directly out of epistemology that began with Aristotle, bore fruit with Hume, Locke and took root in associationists like Thorndike, Watson, Hull and others. In short Bruner's position is that of relationalist and Gagne's position is that of empiricist. Ausubel assumes eclectic approach.

Because of these strong exponents of discovery and expository approaches to teaching, number of studies began to appear in the research literature on teaching. Experts from diversified fields like curriculum specialists, psychologists, and educationists have been undertaking research studies on teaching in different subjects like Mathematics, Science, Social Science, English, Computer programming etcetera. Due to increase in number of studies, reviewing and synthesizing
the results has become a challenge to the investigators working in the field of research on teaching.

Reviewing can be done in two ways:

(i) **Impressionistic Method**: In this method investigator read through the various findings and reaches a series of impressionistic conclusions.

(ii) **Scientific Approach**: Whenever researcher finds an interesting problem, he turns to the previous research. If there are number of research studies in a particular area then he applies precise analytic procedures to the collection of the studies. This is an intermediate step between past and future research. With this intermediate step information regarding a particular controversy is accumulated. If no single answer is uncovered, the investigator may choose to design a new study to improve upon previous efforts. This is known as scientific approach. The researcher used this scientific approach while reviewing the research with respect to expository-discovery controversy.

2.1.0. **STUDY OF TEACHING**:

As pointed out that teaching is very complex human activity. It involves a number of variables and interaction between these variables. These variables are grouped into four categories such as presage, process, context, and product variables.

Since research on teaching should necessarily involve teacher variable, the relationships among teaching variables fall into six classes. These six classes are as under:
(i) **Presage-Product Studies** :- These aimed at establishing the relationship between presage variables (teacher formative experiences, training experiences and properties) and product variables of teaching (pupils' outcomes measured in terms of subject matter learning, attitude towards subject etc.).

(ii) **Process-Product Studies** :- These aimed at finding out the relationship between teacher behaviour and pupil outcomes using systematic observation.

(iii) **Process-Process Studies** :- These aimed at establishing the relationship between teacher behaviours and pupil behaviours occurring in the classroom.

(iv) **Context-Process Studies** :- These aimed at discovering how teaching process varies depending on the context (upper class versus lower class, intelligent pupils versus dull pupils etc.).

(v) **Presage-Process Studies** :- These aimed at establishing the relationship between presage variables (teacher formative experiences, training experiences and properties) and teaching processes.

(vi) **Conceptual Studies** :- These aimed at discovering and understanding the concepts that are useful in research for studying the teaching process.

Taking into consideration these different classes of study on teaching, the researcher reviewed by applying scientific
approach to the studies related to expository-discovery methods only.

2.2.0 PRE-SAGE-PRODUCT STUDIES:

Most of the studies fall under this category. After tabulating and analyzing these studies, they are sub-divided into different sub-groups. These sub-groups are prepared on the basis of the place of research (laboratory, field, classroom) and/or media of teaching (teacher, programmed learning material, computer assisted instruction) and/or interaction between method and pupil characteristics.

i) Studies Conducted in the Laboratory:

Many studies were conducted by the psychologists in the laboratory setting.

Hendrix (1947) made a study of tell and do method, inductive method and unverbalized awareness method. Unverbalized awareness method is a type of discovery method in which the learner is asked to apply a principle or generalization without being able to state that generalization. Two weeks after the generalization was taught, students were tested for 'transfer'. For generation of transfer power, the unverbalized awareness was a better method than tell and do method or inductive method. Verbalizing a generalization immediately after discovery, did not increase transfer power as compared with unverbalized awareness method. This was confirmed by Haslerud and Myers (1958).
A questionable contradiction to Hendrix's study is the study of Craig (1956). Two groups of learners were involved in the study. One group was given guidance and other acted independently (discovery group). After 31 days the group which received guidance (i.e. tell and do method in Hendrix's study) retained a greater proportion of learned relations than the group which proceeded independently (i.e. discovery group). But there was difference in subject matter itself. Craig's study involved subject matter related to word-relations which was less rational in approach than the subject matter involved in Hendrix's study. Hendrix used summation of first n odd integers as the content for the study. Due to difference in subject matter itself the results were contradictory.

Ray (1961) made a study of directed discovery (guided discovery) versus tell and do method in the study of micrometer skills. He found that there was no significant difference in initial learning (measured in terms of knowledge of specific facts, ability to solve problems and actual manipulative performance). There was also no significant difference in retention, one week and six weeks after the conclusion of the experiment, between the two treatments.

Gagne and Brown (1961) experimented on summation of series tasks with guided discovery, discovery and rule-example treatment. On a remote transfer task there was significant difference between guided discovery and discovery in favour of guided discovery. There was also significant difference between discovery and rule example treatment in favour of discovery.
Wittrock (1963) studied the comparative effectiveness of the four treatments (i) Rule given, Answer given, (ii) Rule given, Answer not given, (iii) Rule not given, Answer given, (iv) Rule not given, Answer not given. It was found that groups which were given the rule, decoded more sentences than the groups which were not given the rule. When the rule was not given, giving the answer enhanced learning. The groups with rule not given, answer not given required more time to learn than any of the other groups. The group with rule not given answer not given showed a higher retention score than learning score, while other groups showed a lower retention scores than learning scores. This result was also found by Haslerud and Myers (1958) and Kerah (1958).

Guthrie (1967) also investigated the effectiveness of four methods (i) Rule example, (ii) Example-rule, (iii) Example only, and (iv) no training. The learning task was learning of cryptograms with the help of programmed learning material. He found that 'example only' group was superior on remote transfer to all other groups. Example-rule did not differ from no training group. As far as retention was concerned all the treatments were equally effective but these treatments were superior to 'no training'.

These studies were conducted on the assumption that teaching was the mirror image of learning. It was possible to build up the sound theories of teaching from learning theories. Therefore, in all these studies teacher-behaviour was not
studied at all. Secondly most of the studies were conducted in the laboratory with shorter time sample, and with limited number of subjects. Thirdly in some studies the delayed retention was measured after 24 hours of the completion of the experiment.

Glasser (1966, p.14): Analysis of teacher-behaviour has been neglected in psychological researches, and it has been the most important element in the recent improvements in instruction.

Cronbach (1966, p.26): Criticised laboratory experiments on discovery learning, "The experimental psychologist studies discovery by an isolated learner. Educators however, are concerned with the group instruction in which many pupils face a problem together and all of them throw partial insights into the discussion".

Therefore, in planning the studies on classroom teaching it is desirable that the researcher, should decide about the type of guidance, sequence of teacher behaviours and group characteristics in order to achieve desired objectives.

ii) Field Studies:

The discovery method was not confined to research laboratory only. Due to enthusiastic proponents of this method, many curriculum improvement programmes using discovery method started in various subjects like Mathematics, Chemistry, Biology etcetera. In Mathematics, University of Illinois Committee on school Mathematics Project (UILSM 1963), and Madison Project (Devis 1963) were undertaken.
In UICSM project both inductive and deductive discovery methods of teaching mathematics were used by the teachers in the classrooms. The second important characteristic of this project was the use of unverbalized discovery method given by Hendrix (1947). The materials developed in the project were well organized, sequentially written, and the teachers were trained. These materials were implemented by enthusiastic teachers in the classrooms. As an effect of this project, many pupils started to take interest in mathematics, their power of mathematical thinking increased and they developed versatility in mathematical thinking.

Under the leadership of Davis, the Madison Project, discovery teaching was used for eight years in different grade levels and units chosen from mathematics. The goals of this project were general and non-specific. They wanted to find out some of the best experiences with mathematics that children could have. For choosing the alternatives they relied upon their intuitive assessment. Therefore, this project was not a rigorous research study. But discovery method was found to be effective with respect to students from low I.Q., as well as from culturally deprived communities.

Ausubel (1971, pp. 95-96) commented upon the results of UICSM project that in this programme students learn more mathematics not because they were required to discover generalization by themselves but because they had at their disposal a systematic body of organizing, explantory and
integrative principles which were not the part of the conventional course on secondary school mathematics.

Although these projects were implemented and its efficacy was tested in the field itself, the results of these studies were not compared with the didactic/expository teaching. Perhaps a sound didactic method implemented with the same principles, may result into same outcomes. Since these projects were implemented by the teachers in natural classroom setting on a large scale, the findings of the study were having external validity. Hence while planning the research studies on discovery-expository comparison, features involved in these studies such as, well organized activities, inductive as well as deductive discovery method, well defined language and symbols should be used. Its efficacy should be tested against equally good expository teaching.

iii) Use of Programmed Learning Material, Computer Assisted Instruction etcetera:

With the development of programmed learning technique based on Skinnerian theory of operant conditioning, the researchers developed different types of programmes based on expository-discovery methods of teaching mathematics and in other subjects also. These programmes were used by the investigators in order to control the variability due to the teacher in classroom teaching. These researches aimed at studying the effects of discovery-expository methods of teaching on the achievements of the students. Some of the researches are as under:
Grabber (1974) studied the effectiveness of deductive-expository and inductive-discovery approaches of teaching science on the achievement and retention of ideas in science and on the extension of cognitive and process skills in science. There was no significant difference between the two treatments when the criteria involved initial learning (achievement) of scientific ideas and process skills. But a significant difference was found in favour of deductive-expository method when retention was the criterion variable.

Bunno (1974) experimented in the area of teaching social science with expository and guided discovery treatments. He observed that there were no significant differences between the two treatments on cognitive learning test, retention test (after four weeks), on immediate and delayed transfer test.

Marne (1977) investigated the effects of four treatments of teaching mathematics, (i) Deductive-example only, (ii) Deductive-example and non example, (iii) Inductive-discovery example only, and (iv) Inductive-discovery example and non example only. There was no significant difference as far as concept identification ability was concerned but there was significant difference on concept characterisation ability test (i.e., test comprising the items based on the characteristics of the concepts taught) in favour of deductive methods.
Van Rennes (1978) conducted experiment with four treatments, (i) Teacher led inquiry, (ii) Written inquiry with feedback, (iii) Written inquiry, and (iv) Use of existing museum label only. On the teacher-made-test as a criterion, he found that teacher led inquiry was more effective than written inquiry and label only. And written inquiry was more effective than label only.

Davis (1978) used guided inquiry-discovery approach and expository in order to test the efficacy of these two treatments on the criterion of test based on knowledge of information and concepts, knowledge of science processes and inquiry, and attitude towards science. He found that there was significant difference in favour of guided discovery on the criterion of knowledge of information and concepts and attitude towards science. But there was no significant difference on the test of knowledge of science processes and inquiry.

Pellosi (1979) made a study to test the efficacy of three methods of teaching mathematics, (i) verbal discovery, (ii) non-verbal discovery, and (iii) traditional teaching. He administered immediate and delayed tests, but he could not find any significant differences between the three treatments.

Brain (1981) used the computer assisted instruction technique in evaluating the effectiveness of discovery and didactic methods on cognitive, affective and motivational
outcomes. He found that didactic method was more effective than discovery method on reception and recall of facts and rules, whereas on transfer and explanation, discovery method was more effective than didactic method.

These studies were conducted in various subjects with different criterion variables. But results seemed to be inconclusive. Therefore, use of programmed learning material in order to control the teacher variability did not help the investigators to resolve this controversy. Secondly in almost all schools, at least in India, this technique is not used as a part of daily teaching in classrooms. Development of programmes itself becomes a different kind of study, due to non-availability of programmes on different topics in mathematics. Therefore, use of programmed material to replace the teacher for the research purpose will reduce the applicability of the results in real life situations. These studies did not investigate the interaction of the treatment with pupil characteristics as it is the current trend of research on teaching. But the analytic approach to content, sequencing, entry behaviour test, terminal behaviour test, readability of the written material, and use of reinforcement which are the features of the programmed learning technique, can be used in planning and execution of teaching in classroom by the teacher.

iv) Studies Related to Classroom Teaching:

The studies, where classroom teaching was done by the teacher would be reviewed in this section. These studies related to this group are again classified into different
subgroups depending upon the number of methods of teaching involved in the study, establishing fidelity of the treatment by the investigator during the experiment and interaction of the treatment with pupils' characteristics. This particular sequence determines the increase in precision in scientific approach attained by the different investigators.

(a) Only One Method Research :

In these studies the teacher taught the specific content with discovery method, differing in delay in verbalization of the generalization, or small group versus individual. The effect of variation in discovery approach was tested on pupils' achievement. Two such studies were identified by the researcher and are reported below.

Vernon (1979) studied four sequences of delaying the verbalization of generalization. Immediate verbalization of the rule had destructive effect on acquisition of a mathematical concept. Correction of faulty verbalization by counter examples had negative effect on retention and transfer value. This result concurred with the findings of Hendrix (1947).

Williams (1980) studied the effect of small group discovery and independent discovery on the achievement in and attitude towards mathematics. He found that there were no significant differences among small group treatment as compared with independent treatment. But small group treatment resulted in better attitude towards mathematics.
From these two studies, discovery method had effect on acquisition of mathematical concept and retention and transfer also. Secondly the group size (small or independent discovery) did not have effect on achievement. Since educators are concerned with the group learning and if the group is small (15 to 25), the probability of interaction of each and every student with the treatment will be more. Comparison of efficacy of expository-discovery treatments in small groups would be more preferable than independent discovery.

(b) Two or More Methods Research:

In studies mentioned below, the effectiveness of two or more methods was tested against certain criteria by the different investigators. In these studies teacher variable was controlled either by using the same teacher in both the treatments or thorough training to teachers involved in the study.

Kersh (1958) investigated effectiveness of three treatments, (i) Unguided discovery, (ii) Discovery, and (iii) Expository. The subjects were asked to describe the method of solving the problem on the criterion of transfer, but there was no significant difference between the treatments. But it was found that unguided group produced somewhat greater number of acceptable methods in arriving at a solution.

Kornreich (1969) studied the effectiveness of three treatments, (i) Discovery, (ii) Guided discovery, and (iii) Programmed (didactic). Criterion was 'focussing' strategy for
solving concept-identification problems. It was found that significantly more students in guided discovery acquired the strategy than in the other two groups.

Stanley (1973) studied the effectiveness of three methods of teaching science, (i) Expository, (ii) Inquiry training using high level questioning, and (iii) Inquiry training with low level questioning. The groups were tested by the same test before and after the experimental treatment. Three experimental treatments and I.Q. were treated as covariates. Results of the study showed that the experimental group taught by high level questioning showed significantly higher achievement as compared with the experimental group taught by low level questioning. I.Q. was also found to be an influential variable affecting group achievement.

Francis (1975) investigated the effects of learning by discovery and verbal reception learning on students from different grade levels. The results indicated that discovery subjects took significantly longer time than verbal reception learning subjects to reach the original learning criterion. On all measures of retention and transfer for both simple and complex tasks and for subjects at each grade level, those learning by the verbal reception method were superior to those who learned by discovery.

Curl (1976) studied the effect of inquiry method and lecture-discussion method on logical reasoning, attitude towards mathematics, growth in concrete operation and transitional formal thoughts. No significant differences were found on
logical reasoning and attitude towards mathematics, whereas inquiry group was superior on growth in concrete operational and transitional thoughts.

Blake (1977) found that there was no significant difference on Piagetian tasks when two groups were taught by the method of inquiry and expository.

Muscoriello (1979) studied the relative effectiveness of reception approach and the guided discovery approach and traditional approach in the learning of symptom words. On the criterion of ability to identify symptom words guided discovery group was superior than reception approach. But there was no significant difference between the two treatments i.e. reception and guided discovery approach on the criteria of ability to eliminate symptom words and ability to compose clear sentences. A significant difference was found between reception approach and traditional approach in favour of reception approach on the criteria of ability to eliminate symptom words and ability to compose clear sentences.

Miyan (1982) studied the effects of guided discovery, tell and do and pure discovery on the development of the creativity of the students. He found that there were no significant differences in favour of any of these methods with respect to mathematical creativity, development of fluency and flexibility, convergent and divergent thinking. But guided discovery group was superior with respect to enhancement of originality than the other two groups.
These studies involved different types of criterion variables such as Piagetian tasks, logical reasoning, and creativity, achievement in a particular subject and therefore it was very difficult for the researcher to synthesize the results. There seemed to be no theoretical rationale for selecting the criterion variables for testing the efficacy of expository and discovery methods of teaching mathematics.

(c) Establishment of Fidelity of the Treatment:

Fidelity of the treatment means to assess the degree to which teachers adhered to the prescribed teaching method in each treatment. In earlier researches cited above, it was taken for granted that, whatever the treatment was planned by the particular researcher, it was implemented by the teacher in the classroom as per plan. But there is always gap between planning and performance in teaching in case of live teacher. Since teaching is an interactive process between the teacher and the students there are variations in method at the implementation stage. Secondly, there exists intra and inter teacher variations which cannot be totally controlled through training or otherwise. This variation varies with different pupil characteristics, with different teachers and with different subject matter. Therefore, it is advisable on the part of the researchers to determine the fidelity of the treatment employed in the experiment. The strength of the findings of the study depends upon the degree to which the particular treatment was executed in the class. Following are the research studies where fidelity of the treatment was established by the investigators.
Worthen (1970) investigated the effects of expository-discovery methods of teaching mathematics on the achievement of the 6th grade students. Teachers were thoroughly trained with respect to both the treatments. The fidelity of the treatment was established by the observer's ratings and also pupils' perception of teacher behaviour. Pupils' characteristics such as I.Q., preachievement scores were statistically controlled. On the immediate concept knowledge test, expository method was significantly more effective than discovery method. On the negative transfer test, semantic differential attitude scale, and statement attitude scale both the treatments were equally effective. But on concept retention tests I, II, Written Heuristics Transfer, and Oral Heuristic Transfer, Discovery Method was significantly better than Expository Teaching.

Olander and Robertson (1973) employed treatments expository-discovery, to study the effect on, performance on computation, concept application, principles and relationships. The teachers were rated on a scale measuring the degree to which each succeeded in using the method. Subjects from expository treatment were better in computation, and discovery treatment subjects were better on retention of ability to apply mathematics. Subjects who were scoring lower on pretest gained more under the discovery approach, on principles and relationships. Discovery subjects gained at a greater ratio throughout the study.
Loomer (1976) studied effects of Heuristics and Expository methods of teaching mathematics for one semester. The fidelity of the treatment was established by students' perception about the method. Teacher variable was controlled. There were no significant differences at comprehension, application and analysis levels, retention after one month and attitude towards mathematics and problem solving behaviours.

Fielding (1980) used inquiry oriented and direct instruction methods of teaching social science. Students were matched on sex, and grade point average. Teachers were thoroughly trained with respect to both the treatments. Fidelity of the treatment was established with the help of observation schedule. When knowledge was the criterion, direct instruction was more effective than inquiry oriented teaching. There was no significant difference between the two treatments as far as retention was concerned. Significant interactions were obtained between grade point average and the treatment. High ability pupils performed better in direct instruction where as there was no significant difference between low ability pupils. Direct instruction yielded superior results on knowledge and application.

Selim (1981) studied the effectiveness of discovery and expository methods of teaching science. Teachers were thoroughly trained in using both the treatments. Built on the definition of the discovery and expository, the investigator also designed observation tool for discovery method to aid in
monitoring the study. He found that students taught by
discovery mode had significantly higher scores than expository
method on the criterion of total achievement in science.
Students taught by the discovery method made significantly
higher scores in science attitude than students taught by
expository method.

Since a number of teachers was involved in the study,
the investigators took the care of establishing the fidelity
of the treatment. From these studies it was observed that
direct instruction (expository) was more effective than
discovery method on immediate criterion test whereas discovery
method was more effective with respect to retention. Thirdly,
the treatments were having differential effect on students
with different pre-achievement scores.

Therefore, if only one teacher is involved in the
study, the investigator should take care of establishing the
fidelity of the treatment. Secondly, immediate criterion test
and retention test should be taken into account in judging
the efficacy of the two treatments. Pre-achievement of the
students is also an important variable affecting the later
achievement. Therefore, it should be either controlled
statistically or experimentally. But from the above studies,
it was not possible to find out, what type of pupils were
benefitted by these two treatments.
(d) Studies related to Interaction between Treatment and Pupil Characteristics:

Studies reviewed in captions in 2.2(iv)a and 2.2(iv)b the investigators were interested in finding out the effectiveness of discovery over expository or expository over discovery. But various reviews of the studies on teaching Wittrock (1966), Cronbach (1966) and especially Herman's review of research (1969) on expository-discovery dilemma showed that neither expository nor discovery teaching is consistently more effective than the other. Recently researchers have begun to ask a more sophisticated kind of question. For which students are method of discovery and method of expository teaching appropriate? Success or effectiveness of method depends upon the pupil characteristics and also on the purpose. Therefore, researchers started to study the interaction between the treatment and the pupils' characteristics such as cognitive style, intelligence, high-achievers-low achievers, aptitude etcetera. Some of these studies are reported below:

Thomas & Snider (1969) studied the effects of guided discovery and didactic methods on the acquisition of inquiry skills in science. Students were subgrouped on the basis of sex and three levels of intelligence. Significant interactions were obtained between level of intelligence and treatment but not in respect of sex. The criterion variables were critical thinking appraisal and inventory of science processes. For high ability subjects on critical thinking appraisal measure the guided discovery method was superior to didactic method.
For the subjects of middle and low ability the didactic method was superior. For the criterion of inventory of science processes guided discovery was superior to didactic method with respect to high and low ability pupils. There was no significant difference for the middle ability pupils.

Lahnston (1972) studied the effectiveness of directed discovery and demonstration strategies of teaching geography. 2 x 2 factorial design (one factor method and another intelligence) used in the study. The criterion variables were immediate retention, immediate transfer and trials to mastery. The results of the study showed that the demonstration strategy was more effective than discovery on immediate retention. On the measures of immediate transfer, delayed transfer, delayed retention and trials to mastery, there were no significant differences between the treatment groups. On the intelligence factor, no significant differences were found between high and low intelligence groups on any of the dependent variables. Both the treatments were equally effective for high and low I.Q. groups when time and content were kept constant.

Nelson (1973) designed a study to evaluate effectiveness of expository and discovery lessons on the ability to infer the concept of the students having different cognitive styles. He used the dimension of cognitive style devised by Kagan, i.e. impulsive-reflective cognitive styles. The impulsive person is apt to offer solutions to the problems too quickly without adequate consideration, whereas reflective person likes to be sure as he has the answer right before acting.
Three geometric concepts were presented to these two groups of students having reflective-impulsive cognitive styles. The results of the study showed that expository method was significantly more effective than discovery method on the criterion of ability to infer the concept. Expository lessons did not benefit impulsive students more than reflective students.

Horak (1977) studied the interaction between the method (inductive-deductive) and cognitive style (field dependence-independence). Cognitive style is an individual's preferred mode of problem solving, thinking or learning. He used the dimension of cognitive style described by Witkin, measuring psychological differentiation in the area of perception. Field-dependent people tend to be poor at separating out parts of perceptual field from the whole. There were no significant differences between the two treatments on the criterion scores of test based on knowledge and application objectives. But on the measures of Analysis and transfer, the differences were in favour of inductive method. There was no significant interaction between objectives (knowledge, application and analysis) and cognitive style. But for optimum overall achievement and transfer of learning, the field dependent students showed significant improvement under inductive method.

Wright (1977) studied interaction between instructional methods (inductive-deductive) and style of concept learning in mathematics. The criterion variables were four achievement
tests and an attitude questionnaire. A graph was drawn between scores on concept learning test and achievement test with respect to both the treatments i.e. inductive and deductive. All four sets of criteria yielded a significance region in which deductive method was more effective than inductive method. However, inductive teaching proved to be superior for no segment of concept learning distribution. Deductive and Inductive methods were superior but not statistically significant, among high and low scores respectively, when achievement test scores were criterion measures.

McLeod and Adam (1979) investigated the effects of the levels of guidance (high and low) on the learning of field dependent students in inductive instruction. The achievement test and retention test were used to measure the effectiveness of the method. There was no significant interaction between cognitive style and the treatment. The level of guidance (high and low) had the same effect on different cognitive style students.

From the above studies it is evident that certain characteristics of the pupils are found to interact with the way in which they are taught. Research on these interaction throw some light on the dimensions of teaching that make a difference in student learning. With the help of these types of studies one can prescribe a particular method for a particular type of student for a particular type of purpose. For these types of conclusions, one or more pupils characteristics need to be controlled experimentally i.e. by using factorial design.
The variables like, aptitude, intelligence, cognitive style, pre-achievement scores may be considered for studying such interactions.

2.3.0 PROCESS-PRODUCT STUDIES:

Process-product studies are those studies which aimed at finding out the relationship between teacher behaviour and pupil outcomes using systematic observation. During the past two decades there are a number of research studies related to process-product both in the area of teaching in general and as well as teaching of mathematics in particular. In these studies, the normal classroom teaching of the teachers was observed by the investigators using interaction analysis systems. And subsequently the relationship between specific teacher behaviour (teacher approval/disapproval, teacher talk-student talk ratio, and others) was related to pupils' achievement. These studies were reviewed by Rosenshine (1971), Dunkin and Biddle (1974) and Medley (1979). Although some of the teacher behaviours were consistently and positively related to pupils' achievement, their relationship was not statistically significant. Most of the studies were field studies and teacher behaviours were not controlled experimentally. These studies never analyzed teaching process related to the process of a particular method. Some of the research studies related to the process of the expository-discovery methods are given below:
Peterson et al. (1982) conducted experiment to study the relationship between students' cognitive processes in direct instruction and their later achievement in and attitude towards mathematics. Students' cognitive processes during the teaching process were measured with the help of observation schedule, video-tapes, interview by stimulated recall system and cognitive process questionnaire. The investigator used two way factorial design one factor ability levels (high, medium, low) and other factor attitude (high, low). Some of the major findings of the study were, (i) students who reported that they attempted to relate information to their prior knowledge tended to do better on seat work problems, (ii) students' reports of trying to understand the teacher or a problem, significantly positively related to students' scores on achievement measures and sequential test of educational process.

This type of study may throw some light upon what is going on in the classroom and its relationship with product.

2.4.0 TREND OF RESEARCH ON TEACHING:

A number of research studies related to expository-discovery controversy have been reviewed up till now. Sage (1979, p.93) pointed out that, "The research findings will dampen much of oscillation of educational fashion—between progressivism and traditionalism, open education and direct instruction, heuristics and didactic teaching. None of
these ways of teaching will pass from the scene but they will be used with better understanding of the value each can help to achieve. Controversies over purposes will persist." But reviewing the research studies from a particular area, one can understand the phenomena in a better way. Through these studies one gets facts upon which one can build an image of a future study, and through research, one can transform this image into facts. In order to get facts about the controversy between expository-discovery methods of teaching, one must study the trend of the research, not strictly chronologically but by the trend of ideas generated by these researches.

The first set of studies focussed on studying the effectiveness of discovery method on the achievement of the pupils. By varying the degree of guidance and structure in discovery approach, the effects were studied by the investigators without comparing with didactic teaching.

The second set of studies tried to study the effectiveness of two or more methods on various criterion measures. These studies never looked into the classroom where the teaching process was going on. These studies neither concentrated on process of teaching nor on the pupils' characteristics. These studies tried to find out a single best method for all types of pupils and all types of subject matter and for all types of purposes.
The third set of studies investigated the effectiveness of the treatments on the achievement of the students by determining the fidelity of the treatment. These studies attempted to establish the validity of the treatments. In some of these studies, the initial differences in pupils' characteristics were controlled by ANOCOVA. By applying ANOCOVA technique, the scientific rigour was reached by the investigators, but in these studies also, they could not get conclusive results.

The fourth set of studies controlled pupils' characteristics experimentally by using factorial design. The pupils' characteristics such as cognitive style, intelligence and others were controlled experimentally, but these studies did not partial out the initial differences in the pupils' abilities.

The fifth set of studies tried to correlate various specific teacher behaviour with pupils' achievement by observing the normal classroom teaching of the teachers. Although some of the teacher behaviours were consistently and positively related to pupils' achievement, the coefficients of correlation were not statistically significant. Theoretically also, teaching learning process is so complex that it is very difficult to get high and significant correlation between any teacher behaviour and pupils' achievement, unless some sequence of teaching behaviours are repeated for a number of times.
The sixth set of studies focussed on the process-product relationships. Various ratios like indirect-direct ratio, student-teacher interaction, teachers'-students' cognitive processes were related to pupils' achievement.

Very little educational research has included systematic measurement of classroom process till this date with respect to expository-discovery controversy. But due to development of category system, the investigators have been trying to look into classroom teaching processes. Researchers studied the interaction between the treatment and the pupil characteristics with respect to product variables as mentioned in caption 2.2.(iv) but variation in method due to interaction with the different pupils' characteristics was not studied by the investigators.

Gage (1979, p.17) said that variations within classroom are worth studying and that teaching especially in its socially interactive forms, must entail some artistry.

Brophy (1979, p.46) suggested further trend of research on teaching. According to him, 'Researcher should develop and solidify an empirical base of reliable information about process-process and process-product relationships'.

2.5.0 IMPLICATIONS OF THESE STUDIES:

There are number of research studies with respect to expository-discovery. But in India the researcher could identify only one research study namely that of Miyan (1982)
with respect to expository-discovery controversy. There are no research studies with respect to this controversy which is evident from two surveys of educational research in India (Buch 1972, 1979) and R. Govinda (1982). Therefore, it is necessary to undertake a number of research studies with respect to expository-discovery dilemma. The present investigation is an humble attempt in that direction. While reviewing the studies, the researcher felt gaps in the earlier research studies. Implication of these studies are given below:

i) Most of the research studies are presage-product in nature. The investigators did not analyze these methods at micro level. Therefore, in order to conceptualize these methods it is necessary to analyze the teaching-learning process with respect to expository-discovery methods of teaching mathematics.

ii) There is need to study, teacher behaviours and pupil behaviours involved in the expository-discovery methods. Process-process study can be undertaken.

iii) Method varies according to intellectual abilities of the pupils. How expository-discovery method varies according to levels of intelligence of the pupils, needs to be explored.

iv) What are the determinants of the difference in products with respect to expository-discovery methods? This can be answered only by undertaking process-product study in this area.
v) Pre-achievement and intelligence are the two important factors affecting the subsequent achievement. There is interaction between intelligence and the treatment. In some of the studies I.Q. was either controlled experimentally or statistically. Similarly, pre-achievement was controlled statistically. But in none of the studies these two factors were controlled simultaneously. These two can be controlled simultaneously by employing factorial design with covariate only.

vi) While designing the research study in the area of teaching methods, immediate learning as well as retention should be taken into account as criterion variables.

vii) Teacher variable should be controlled. Fidelity of the treatment should be established.

viii) Both verbal and non-verbal activities in the mathematics classroom should be observed and these should be kept identical in both the treatments.

ix) Intervening variables, contamination between the two treatment groups and intra teacher variation should be minimized.

x) In recent studies on expository-discovery controversy, the investigators have been using objectives of instruction as criterion variables. These objectives help the investigator both at planning of teaching and studying effects of teaching.
xi) Effectiveness of expository-discovery should be judged within the available time to the teachers for teaching a particular unit.

xii) ANOVA and ANCOVA are the widely used statistical techniques for the data analysis by the investigators. These should be used for the data analysis.

Taking into consideration the above implications of all these studies the present investigation is designed by the researcher which is described in following chapters.