CHAPTER ONE

INTRODUCTION

1.0.0.0 PROLOGUE

The study is entitled, as 'A study of the Effects of Different Methods of Teaching Science on the Achievement, Basic Science Process Skills and Scientific Attitude of Pupils with Different Achievement Levels'. has been conceived in the context of science teaching especially at the upper primary stage. It is an experimental study where an attempt has been made to provide additional input into the three selected Methods of Teaching Science by studying the teaching process associated with each of the methods with respect to different achievement levels. It is intended to find out whether the specially designed instructional material developed by the investigator under the three different Methods of Teaching Science selected for the study would improve the Scientific Attitude of the pupils; to find out whether it would improve the Basic Science Process Skills of pupils and to find out its effects on the Achievement of pupils in Science.

This problem has been conceived keeping in mind the following:

i. The nature and concept of teaching and the teaching cycle;
ii. Research on teaching and the variables of research on teaching;
iii. Status of research on science education in India;
iv. Status of research on science teaching at the school level;
v. Desired status of science teaching at the school level, and
vi. Future research trends in science teaching.

This Chapter presents the explanation and discussion on the above issues under the captions, Nature and Concept of Teaching; Teaching Cycle which covers Teaching Strategies, Methods, Patterns and their inter-relationships; Status
of Research on Science Education in India; Status of Research on Science Teaching at the School Level; Future Research Trends in Science Teaching and Need for the Study. The rest of the sections presents the Paradigmatic Perspective of the Present Research. Statement of the Problem, Objectives of the Study, Operational Definitions of the Terms used and Assumptions of the Study. The Chapter ends with a discussion on the scope and limitations of the study.

1.1.0.0 NATURE AND CONCEPT OF TEACHING

During the last three to four centuries, the concept of teaching has been constantly evolving. Educationists, Philosophers, Psychologists, Sociologists and Scientists have, at different periods of time, tried their best to understand the nature of this humane activity called teaching. Based on their observation and experiences, they have defined teaching in various ways. Efforts to define “teaching” have centred on explorations of various facets of the concepts of teaching rather than on the formulation of explicit definitions. In order to study the meaning and nature of teaching a set of definitions are analyzed below under four subsets, according to their stress on the source of reality, the focus of attention, on the nature of learning outcomes and the learners’ environment. These four sub-sets are:

i. Teaching as an Intentional Humane Activity;

ii. Teaching as an Interactive Process aimed at Desirable Products called Learning;

iii. Teaching as Helping the Child to Respond to his/her Environment Effectively, and

iv. Teaching as a Relationship.

1.1.1.0 Teaching is an Intentional Humane Activity

The definitions given under this subset deal with a stress on the acts of the teacher in order to bring about change in the learner.
i. Gage (1963, p.96): Teaching is an interpersonal influence aimed at changing ways in which other persons can or will behave.

ii. Hough and Duncan (1970, p.20): Teaching is an activity – a unique professional, rational and humane activity in which one creatively and imaginatively uses himself and his knowledge to promote the learning and welfare of others.

iii. Mitra (1972, p.22): Teaching is a series of acts carried out by a teacher and guided by formulation of the teaching task in a formalized instructional situation.

All these definitions have given the stress on the act of the teacher in order to bring about change in the learner. From Gage's definition it is clear that teaching involves more than one person the behavioural influence of one-person changes the behaviour of others. In their definition Hough and Duncan have stressed the involvement of more than one person in the teaching act, and have given teaching the status of a professional, rational and humane activity. Teaching has also been seen by them as a creative and imaginative activity. In Mitra's definition the stress is on a series of teacher acts guided by the teaching task.

1.1.2.0 Teaching is an Interactive Process Aimed at Desirable Products Called Learning

Persons like Flanders, Amidon and Hunter, after analyzing classroom teaching with the help of different category systems, have put forth definitions of teaching which belong to this subset. According to them teaching is a process of interaction between the teacher and the student.

i. Hughes (1963, p.27): Teaching is interaction. Here interaction means the partners or objects in a situation act upon each other. Therefore, teaching cannot be separated from the learner.

ii. Amidon and Hunter (1966, p.1): Teaching is... an interaction process, primarily involving classroom talk, which takes place between the teacher and the pupils and occurs during certain definable activities.
iii. Flanders (1970, p.1): The act of teaching leads to reciprocal contacts between the teacher and the pupils: and the interchange itself is called teaching.

iv. Bidwell (1973, p.414): Teaching may be defined as a series of interactions between some one in the role of a teacher, and someone in the role of the learner, with the explicit goal of changing one or more of the learner’s cognitive states (what he/she knows or believes, or his/her skill in performing cognitive tasks) or affective states (his/her attitudes, values or motives). In its aims teaching is coterminous with socialization; it is distinctive in the social definition of the interpersonal relationship that it involves.

All these definitions say that teaching is an interactive process aimed at desirable outcomes called learning. Here interaction takes place between the teacher and the learner/pupil.

1.1.3.0 Teaching as Helping the Child to Respond to his/her Environment Effectively

Definitions given by learning theorists like Thorndike, Skinner, Joyce and Weil and Good belong to this subset. The emphasis of these definitions is on the learning environment and the teacher is expected to create the necessary situations conducive to learning.

Thorndike (1913): Teaching is the arrangement of situations, which leads to desirable bonds and makes them satisfying.

Gagne (1978, p.23): Instructing means arranging the conditions of learning that are external to the learner. These conditions need to be constructed in a stage by stage manner, taking due account at each stage of the just previously acquired capabilities of the learner, the requirements for retention of these capabilities, and the specific situations needed for the next stage of learning.

Skinner (1968, pp.64-65): Teaching is the arrangement of contingencies of reinforcement under which students learn. They learn without teaching in their natural environments but teachers arrange special contingencies that expedite
learning, hastening the appearance of behaviour, which would otherwise, be acquired slowly, or making sure of the appearance of behaviour which might otherwise never occur.

Joyce and Weil (1980): Teaching is a process by which the teacher and students create a shared environment including set of values and beliefs (agreements about what is improvement) which in turn colour their view of reality.

Good (1959): Teaching implies the management by an instructor of the teaching learning situation including:

- Direct interaction between teacher and learner.
- The pre-active decision making process of planning, designing, preparing the materials for the teaching learning conditions, and
- Post-active redirection (evaluation, redesign and dissemination).

All these definition stress the importance of a learning environment. In addition to the learning environment the definitions of Joyce and Weil and Good stress on the teaching process.

### 1.1.4.0 Teaching as a Relationship

The definitions, which stress on the relationship between three focal points in education, the teacher, the pupil and the subject belong to this subgroup and are given below.

Henderson (1963, p.1007): Teaching can be conceived as the ternary relation: X teaches Y to Z. Expressed in the notation of relational theory this becomes (XY) TZ or more generally T (X, Y, Z).

As popularly conceived, the domain of ‘X’ in the set of persons who act as teachers, the domain of ‘Y’ is the set of knowledge, beliefs or skills selected by the teacher; and the domain of ‘Z’ is the set of individuals humans and other animals capable of modifying their behaviour as a result of experience – who are taught by the teacher. This definition is more comprehensive and takes into
account all facts of the teaching – learning process. Moreover, this definition offers a direction in developing and analyzing research on teaching.

Jones and Bhalwanker (1990): Extended the definition given by Henderson as $W, X \rightarrow Y \rightarrow Z$, where ‘$W$’ is an environment created by the teacher. ‘$X$’ stands for teacher, ‘$Y$’ is the subject selected by the teacher, ‘$Z$’ is the pupil or set of pupils who are taught by teacher.

1.1.5.0 Implications of these Definitions

From the analysis of the above definitions, the following aspects of teaching are revealed:

i. Modification of environment conducive to learning;

ii. A process of interaction which is the core of teaching process;

iii. Interaction process directed towards predetermined goal, and

iv. Interaction process inclusive of verbal and non-verbal activities of the teacher and the students.

Taking into consideration these aspects, teaching can be redefined as an interactive process between the teacher and the pupil in a classroom situation with predetermined goals or objective to be achieved.

Burns (1980, p.793) has pointed out that researchers have usually employed outcome measures at the end of the instruction to quantify learning while ignoring changes that occur during learning. But it is the process of change from ignorance to competence, which should be the major focus of instructional psychology.

Therefore, evaluating the effectiveness of the two or more teaching strategies, outcomes at the end of instruction as well as, outcomes during the interaction process itself should be taken into account. If one takes into consideration these criteria for judging the effectiveness of teaching one must try to develop some criteria for judging the effectiveness of teaching during the interaction process itself. For the development of such criteria a careful analysis of the interaction process is essential. These criteria can be developed on the basis
of student’s responses during the interaction process. Pupil’s initiation ratio, rate at which learning is taking place, corrective feedback, and motivational statement ratios can be considered for the development of such criteria.

Therefore, for the present and future studies on teaching, the definition of teaching can be restated as:

Teaching is an interactive process between the teacher and the pupils in the classroom situation with predetermined objective to be achieved, and its effect can be measured in terms of both immediate and intermediate product variables.

1.2.0.0 TEACHING CYCLES

Teaching is an intentional activity, which assumes its distinctive character and meaning not in isolated behaviours, but in sequences of interrelated acts. The concept of “teaching cycles” is the product of one attempt to describe communication pattern in the classroom in terms of sequences of smaller units of verbal behaviour.

In the study of Bellack et al. (1966), teaching is conceived as a type of “language game” in which the players’ (teachers, pupils) make “pedagogical moves” comparable to moves in a game of chess. Moves are classified according to their functions in classroom discourse, these classifications being soliciting, structuring, responding and reading. As in a game of chess, teachers and pupils employ tactics and strategies to achieve their purposes. Hence, moves tend to occur in logical sequence or cyclic combinations, which Bellack et al. designated “teaching cycles”. Teaching cycles, then, are distinctive sequences of inter-related pedagogical moves, which can be described in terms of certain patterns of moves and the relationship of moves to each other.

These sequences are classified into various meaningful categories such as strategies, methods, patterns and others. If the investigator is interested in finding out the relationship between a particular sequence and the achievement of the students, then that particular sequence should be repeated for several times and its validity should be established on the basis of empirical support.
A confusing diversity of terms and approaches have been employed in the study of sequential patterns of interaction. Therefore, to explore the relationships between strategies, methods and patterns in the following subsections the definitions of these terms are given and relationships between these sequences are established at the end of this Section.

1.2.1.0 Teaching Strategies

Smith et al. (1967, p.3), considered that a strategy is a way of looking at activities involved in classroom discourse. It refers to a set of verbal actions that serves to attain certain results and to guard against others. There are two dimensions of a strategy, namely, the treatment and the control dimensions. The treatment dimension concerns with the type and sequence of operations that the teacher and the pupils jointly enter in setting forth and structuring information in such a way as to disclose the content that is to be learned. The control dimension deals with operations on the content.

Smith and Maux (1970, p.3), referred to strategy as a pattern of acts that serve to attain certain outcomes and to guard against certain others. The pattern of acts need not refer to only ‘set of verbal behaviours as given by Smith et al. (1967).

Hough and Duncan (1970. p.164) defined strategy ‘as a pattern of substantive, managerial, or silent behaviour used to facilitate students’ attainment of an objective’. Further it is composed of a series of moves, where a move is defined as a single event that starts with the initiation of behaviour and ends with its transition to another behaviour. But strategies do not involve all types of teaching behaviours. They are often used with tactics. A tactics is defined as a pattern appraisal behaviours used to support the primary instructional pattern, that is, the strategy. For example, a teacher asking a question followed by a move to students’ response and students’ response followed by a move to another question forms a strategy. This strategy is supported by appraisal behaviour such as confirmation and corrective feedback.
Frankel (1973, p.176) considered teaching strategies exclusive of pupils learning activities. Teaching strategies refer to the operations a teacher performs in order to involve the students in activities and represent things which students do or action in which they are engaged. This idea of teaching strategy involves only teacher behaviours and not pupil behaviours.

### 1.2.2.0 Teaching Methods

Dictionary of Education, Good (1973, p.363) defines:

i. **Method** as an established or systematic order for performing any act or information, and

ii. The relationship established by an educational institution with a group of participants, for the purpose of systematically diffusing knowledge among them.

These two definitions of the term clearly indicate two important aspects of the method:

i. Systematic organization, and

ii. Imparting knowledge—the focus of act

Henderson (1963, p.1007): A pattern that is a set of common properties that a set of behaviour manifests will be called a method.

According to Broudy (1963, p.2), Method refers to the formal structure of sequence of acts, commonly denoted by instruction. The term method covers both strategy and tactics of teaching and involves the choice of what is to be taught.

Gage (1969, p.1446): “Teaching methods are patterns of teacher behaviour that are recurrent, applicable to various subject matters, characteristic of more than one teacher, and relevant to learning”. Teaching methods so defined refer to a human teacher and may be considered a subcategory of educational methods, which also include instructional devices (educational methods that employ non-human media), such as teaching machines, conventional and programmed text books, simulators, films and the like.
A pattern of teacher behaviour refers to a set of behaviours that occurs either simultaneously or in sequence in a unified way. In the Lecture Method, for example the pattern consists of an uninterrupted sequence of oral statements by the teacher, in classroom discourse. Bellack and others (1966) found out that “The fundamental pedagogical pattern of discourse consisted of a teacher’s solicitation followed by a pupil’s response; this sequence was frequently followed by a teacher’s reaction”. Here the component behaviours are the teacher’s asking a question, the pupil’s response, and the teacher’s reaction to rating of the pupil’s response; their occurrence in a given sequence constitutes the pattern, and the recurrence of the pattern constitutes a teaching method.

By recurrence is meant the repetition of the pattern of teacher behaviour over intervals measured in minutes or weeks. The interval depends on the duration of the behaviour pattern and the frequency of the occasions on which it is used. Some patterns recur frequently, that is, every few minutes or every hour. But a pattern may be used as infrequently as one year, as when certain methods are used for teaching subtraction or the meaning of allegory.

A teaching method is typically applicable to more than one topic or specific objective. At one extreme, a special teaching method may be applicable to only one objective, such as demonstration of a proof in teaching ability to recall the Pythagorean theorem. A general teaching method can also be applied to a whole course of study, such as the Discovery Method in Secondary School Mathematics or the Lecture Method in Introductory Sociology. In its most general sense, teaching methods, such as the Lecture Method or the Discussion Method is applicable to all subjects.

A teaching method must be usable by more than one teacher. If a pattern of behaviour is unique to one teacher and unavailable, for whatever reason, to other teachers, it is not regarded as a teaching method. In this respect, a teaching method is comparable to a ‘role’ as defined by Social Psychologists. That is, it involves a relatively uniform set of behaviours expected of persons occupying a given position, such as lecturer or discussion leader. Variations of behaviour
within the teaching methods, or role, are then attributed to the ‘personality’ of the teachers (cf. Getzels and Jackson 1963).

1.2.3.0 Patterns of Teaching

An event is the shortest possible act that a trained observer can identify and record. Often during classroom interaction the same sequence of events occurs again and again and such a sequence is called a ‘pattern’. A pattern is thus defined as, ‘a short chain of events that can be identified, occurs frequently enough to be of interest, and can be given a label (or name) since this often facilitates thinking’ Flanders (1970, p.40.)

1.2.4.0 Strategies, Methods and Patterns – Their Interrelationships

Various terms, as mentioned in Section 1.2.1.0. to Section 1.2.3.0. have been used by different researchers to focus upon certain sequences of teaching behaviours that form a part of classroom processes. All the three deal primarily with the sequence of teaching behaviours differing in their complexity.

Strategies are more general in nature and deal with approaches such as Discovery, Inquiry, Inductive and Deductive. These are based on the logical analyses of the content. But whatever are the steps/moves of the strategies, these may not be readily applicable in a particular lesson because of the constraints of content, pupil, time, and resources available. Therefore, the teacher has to adopt/modify these strategies to suit the particular situation. Then these strategies are converted into teaching methods, that is, Demonstration Method, Guided Discovery Method, Project Method, and Cooperative Learning Method. Thus, a method is a wider term, which includes strategies and techniques of teaching. Different strategies may be adopted in following a method. Different patterns (techniques) may be used within the same strategy and method.

When a particular strategy method is implemented in an actual classroom, by interaction with different types of pupils, it is translated into different teaching patterns. Therefore, teaching patterns are observable forms a particular teaching
strategy or method. Therefore, when strategies interact with content, these are translated into different methods. One can use one or more strategies in one method only. When a method interacts with pupils in the classroom setting, it gives rise to different teaching patterns.

1.3.0.0 RESEARCH ON TEACHING

Research on teaching usually involves the measurement of two or more variables of different types and the study of the relationships between them. Only those studies in which one or both of the variables lie on the line between pre-existing teacher characteristics and pupil learning outcomes can be described as research on teaching. This is very much stressed in the definition given by Gage (1963, p.97); we define research on teaching, as research in which at least one variable consists of a behaviour or characteristic of teacher.

Research on teaching is research based on the assumption that the quality of teaching that goes on in today’s schools varies widely and the overall strategy of the research is to try to find out why to find differences in other teacher characteristics that account for this variation. Implementation of this strategy requires first of all a conception of what good teaching is, next it requires a valid instrument or device which will distinguish good and poor teaching as conceptualized, and instrumentation for measuring the ‘explaining’ variables, validly and reliably is also essential. Third, there must be a design or plan for collecting accurate and valid data about these variables and finally an analytic procedure is needed for extracting from the data all of the information about the relationships that they contain.

Studies of research on teaching could be classified into different classes depending upon the nature of variables and its relationship with other variables involved in the study.

As defined earlier, teaching could be conceived as a ternary relation T (X, Y, Z) from which one can abstract many relationships:
i. If \( X = Z \) in the relation, then the person is characterized as self taught or self educated;

ii. A second kind of study focuses on the binary relation \( YSZ \). This kind of research is known as curricular research, and

iii. The third kind of research focuses on the binary relation \( XRZ \). This is called as the methods research.

### 1.3.1.0 Methods Research

A method of research focuses on the relation between the method the teacher (person, text, or machine) employs and those behaviours of a student, which under various hypotheses are related to methods. There are three general approaches to undertake this type of research:

i. Teaching is a necessary condition for a certain kind of student behaviours.
   \[ \text{If } X \text{ then } Z, \ X \rightarrow Z; \]

ii. Teaching is a sufficient condition for a certain kind of student behaviours.
   \[ \text{If } Z \text{ then } X, \ Z \rightarrow X, \text{ and} \]

iii. Teaching is both necessary and sufficient for certain kind of student behaviours. \( X \) if and only if \( Z, \ X \rightarrow Z. \)

Methods research can be classified into two categories depending upon the number of methods of teaching involved as a variable in the study. They are:

i. Only one method, and

ii. Comparison of two or more methods.

### 1.3.1.1 Single Method Research

This type of studies deals with an argument in favour of one particular method. These type of studies advocate a particular method for social utility or applicability to real life situations or development of certain kinds of characteristics in the students.

Studies of Slavin (1983), Christian (1990), Cooper (1995), Sowder (1969) belong to this category. These studies are quoted in Chapter Two.
1.3.1.2 Comparison of Two or More Methods

Most research on methods follow an “experimental” format in which two or more methods are compared in terms of their effectiveness in producing student learning or attitudes. Typical comparisons include Lecture versus Discussion, Discovery verses Expository and Cooperative versus Individualistic Learning. These comparative approaches are also characterized as studies of instructional media in which the effects of programmed instruction, television, films and computer assisted instruction are compared with each other or with ‘traditional’ teaching. One variation on the comparative model is research on Attribute by Treatment Interactions (ATIS) which focuses on interactions between conditions of instruction and attributes of learners rather than on simple main effects. The ATI paradigm provides one means of bringing individual differences among students into research on teaching.

In short, the investigator tries to find out certain behaviours of students, which can reasonably be considered related to the method employed. In this type of research the investigator is interested in finding out a method which is a sufficient condition for the manifestations of certain behaviours by the students.

But different reviewers of research on teaching, Gage (1963) Rosenshine (1970), Travers (1973), Dunkin and Biddle (1974), generally hold the view that change in pupil’s behaviour seemed largely unaffected by style of teaching. Therefore, Wallen and Traverse (1963, p.494) concluded, “The era of research comparing one teaching method with other method is coming to an end”.

Wittrock (1966, p.37) opined that “Individual difference may require several approaches” and stated that “with variety of subject matter and students encountered in schools, it is surely futile to expect one method of learning to be consistently superior or inferior to other plausible procedures”.

In other words, to evaluate the effectiveness of different teaching methods with reference to different content matter requires data on their consequences for different types of pupils. Therefore, researchers should study the differences in what is taught and the pupils to whom it is taught.
But the investigator of the present study is of the opinion that research should study the difference in how the content was taught and the pupils to whom it was taught and for what purposes it was taught. With these types of studies one would be able to make the statements like: for content material Y, taught by teacher Q to pupil Z, the best method is X. Therefore, with this logic as a background, the investigator decided to undertake a research study on Teaching especially on Science Teaching.

1.4.0.0 Status of Science Education in India

The status of science education is our country can be looked at from the points of view of the status of research on science education, research on science teaching at the school level, desired status of science teaching at the school level and future research trends on science teaching. These are discussed in following subsections.

1.4.1.0 Status of Research on Science Education in India

The status of research on science education in India has yet to grow. The study on position of science education in India reported by Bose et al. (1983) correctly, assessed that,

"The state of research in science education in our country has not been encouraging. It has almost remained restricted to the areas of instructional material, methodology of teaching, resources and facilities available in schools for teaching science"

According to the First Survey of Research in Education done in our country up to 1970 (Buch, 1974) there is hardly any study recorded in this area. The Second Survey (Bcuh, 1979) observes that science claimed significantly a few studies which are mainly concerned with the trend, course of study and teaching of science. Ganguli and Vashistha (1991) listed 101 researches in eight areas, which were conducted during the four surveys, including their own research. In the Fifth Survey, like in the Fourth Survey, the number of studies has
not changed (61 studies). Therefore, the frequency of researches conducted over the five surveys up to 1992, was just meager total of 172 studies. Studies in science education are mainly carried by educational agencies, colleges of education or the universities and individual schools.

Singh and Jaimini (1992) in their trend report on ‘Teaching Strategies’ in the Fifth Survey of Educational Research reported that the research studies on teaching strategies have by and large, been of the presage-product type, that is, simply measuring the outcome of an instructional process. In order to have a more comprehensive and closer-to-reality interpretations, the research designs could be Presage-Process as well as Presage-Process-Product. Most of the studies have been conducted on secondary level learners and teacher trainers. There is scope for studying the efficiency of teaching strategies at the primary level for learners with special educational needs, such as underachievers gifted and handicapped (physically or mentally) learners. They have also pointed out that in majority of the studies the dependent variable was generally, the achievement score of the learners which is a macro-level variable, assumed to be of normal distribution, whereas there is a need to take criterion referenced variables at the micro-level.

Thus, it is evident that research studies need to be undertaken at the primary level for the learners with special needs. And researches on the effectiveness of methods need to be studied on the basis of criterion referenced variables at micro level.

1.4.2.0 Desired Status of Science Teaching at the School Level

Before exploring into how science teaching should be, it would be more appropriate to examine the nature of science as perceived recently and the psychology of science teaching.

The nature of science is not easily delineated but it has been put forward by different Scientist and Educationists, highlighting the different emphasis given to the meaning of science. Three definitions of science quoted in Potter (1978) are given and discussed below.
“Science is first of all a set of attitudes. It is a disposition to deal with facts rather than with what someone has said about them” (Skinner in “Science and Human Behaviour”).

“Science is not a technique or a body of knowledge, though it uses both. It is rather an attitude of enquiry, of observation and reasoning with respect to the world. It can be developed, not by memorizing facts or juggling formulas to get an answer, but only by actual practice of scientific observation and reasoning” (Compton).

“Science should be recognized and taught as a major human activity which explores the realm of human experience, maps it out methodically but also imaginatively, and by disciplined speculation creates a coherent system of knowledge” (Policy Statement ASE-1965).

He summarizes the meaning of science from the above definitions and suggests that the nature of science is a composite term comprising three mutually interpenetrating components. These components are given below:

a. **The nature of scientific method:** It is derived from the philosophy of the discipline and cannot be prescribed or formalized. It is a powerful means of extending man’s predictive power upon the universe, and allows data gathering and theorizing to come together. The method is characterized by the bringing together of those processes and practical skills of observing, classifying, looking for patterns, measuring, attempting to explain, communicating, predicting, experimenting and drawing conclusions, which allow scientists to explore the properties of the universe, manipulate the materials of the world and search for patterns and processes inherent in natural phenomena.

b. **The body of knowledge:** Scientific knowledge accrues when the scientific method is applied to problems derived from the exploration of the universe. This body of knowledge can be further divided into strata whose boundaries encapsulate the knowledge of the separate science discipline.
In other words, the nuances of the separate science are essentially nuances of content and not of method. The nature of scientific knowledge is such that it is: empirical, probabilistic, reproducible and holistic.

c. **An influence on the environment and man:** Scientific knowledge affects man’s relationship with his environment; it changes man’s whole being in accordance with reason. This knowledge, therefore, becomes a social influence and an essential part of culture. The Scientist has a social responsibility, which should not be considered extrinsic to science, and no culture could possibly be relevant to the needs of society if it continued to ignore scientific insights and innovations.

There have been developments in the philosophic perspectives about the nature of science. Bacon’s empiricism – inductivism requires the observer to observe, analyze and record with no underlying hypotheses except those that relate to the logic of the thinking processes. According to this perspective, observation, classification, and application of logic lead to understanding of the observed data. The logical positivism perceives science as meaningful, if it is directly found on experience (Potter, 1978). According to this, the individual attains meaningful knowledge only from sensory experience with the physical environment. One among the chief proponents of such a philosophy, who has influenced tremendously the science education in the United States of America, is Gagne. According to him (Gagne, 1970) inquiry begins with observation and proceeds through the systematic organization of data, the inductive formation of inferences, and the testing of those inferences. Such inquiry is based upon concepts inductively inferred from discrete sensory impressions that are similar and contiguous. As regards instruction, the implications derived from the above viewpoints are that, students should be provided with opportunities to learn the science processes while they are engaged in laboratory activities. The student should be taught to enquire, when learning the inductive method of problem solving (Finley, 1983).
Modern philosophers of science (Kuhn, 1970; Popper, 1959; Toulmin, 1972) view that science proceeds in the light of available conceptual knowledge. This conceptual knowledge determines the problem for a discipline, the hypothesis and what and how of data, how observations will be classified, and in main what the observer would consider as the relevant fact. Such a philosophic perspective about the nature of science questions the epistomologic foundations of inductivist empiricist view. However, this does not imply that emphasizing the teaching of science processes to students while learning science is less important but what it implies is, both processes and content goals should direct science programmers. Thus, processes can be seen as playing an important part in the building of concepts, which gradually become more powerful and widely applicable. Concepts enable processes to be refined, so that the phenomena of increasing complexity can be understood (Harlen, 1985).

Looking deeply into the nature of science, its auto-acceleration, two aspects of education and its aims of teaching at school, it becomes quite clear that, as far as possible, teaching of science to its young students should include proposing problems, refining and defining them more productively, setting up hypotheses and their testing with the help of controlled experiments, thinking out new solutions, discarding personal opinion in the light of new evidence and suspending judgement in case of conflicting evidence, discarding even the principle of authority, if found necessary, and in short, distinguishing between scientific information and popular information and beliefs. These initiations and expectations should be brought down to the children’s level of experience, comprehension and followed up later on to promote the quality of reasoning as the children go up the school ladder. These visualized behaviour changes, among the body of children, are referred to here as the outcomes of science education (Vaidya, 1996, p.65)

These outcomes in this light are stated below:

1. Functional Understanding
   a. Scientific vocabulary
b. Scientific fact
c. Scientific concept
d. Conceptual scheme
e. Application to new phenomena

2. Scientific skills
3. Scientific attitudes
4. Scientific interests
5. Scientific appreciation

This requires the children to learn science by doing and not by hearing science. They need to explore and experience nature and observe the world around them, measure, classify, infer and arrive at generalizations.

Hence, the objectives of teaching science at the primary school level should be arrived at:

i. Arousing and maintaining interest in nature and in the physical and social environment and arousing love for nature and habit of nature and its source;

ii. Developing the habit of observation, explanation, classification and systematic way of thinking;

iii. Developing the child's power and inventive facilities, and

iv. Developing neat and orderly habit and inculcation of habits of healthful living.

Therefore, at this stage, science education must attempt to reflect the components of science:

i. The body of knowledge;

ii. The method of making inquiry a way of investigating, and

iii. An attitude towards life; away of thinking.

Hence, the science teacher at this stage has a challenging job of actively involving her students, so that the nature of science pervades the instruction. Science as a body of knowledge, a way of investigating, and a way of thinking should be stressed in science teaching activities, projects, demonstrations,
assignments and others. The pupil has to tackle his/her own set of problems in his/her own education and that too in a wider setting. The solution is in some principles of teaching (Vaidya 1996, p.159).

These are:

i. **Be realistic:** Attempt all those diverse activities which are both within the capabilities of the teacher and the students;

ii. **Work in a wider setting:** Creating abundant opportunities for learning, encourage individual and small group work;

iii. **Stress active learning:** Be a guide as well as a diagnostician. Maintain free atmosphere to learn;

iv. **Encourage quantitative learning, and**

v. **Follow spiral learning.**

Therefore, the main goal in science instruction should be to begin with each pupil where he/she can create an educational climate to bring about the maximum development in him/her.

This is the fundamental principle of the constructivist theory. Therefore, a brief discussion on the cognitive constructivist perspective of science learning is also discussed in this Section.

**Constructivist Perspective of Science Learning**

The studies that share the greatest continuity with earlier research on student thinking and learning in the classroom are those studies that have a broadly defined ‘cognitive’ perspective on student experience. With the development of cognitive science and the concept of ‘cognition’ as a way of understanding all mental processes, the careful distinctions that used to be made between concepts such as learning, thinking, problem solving, and remembering are no longer tenable. As a consequence, it no longer makes sense to talk of knowledge simply as a behavioural response or as a kind of substance that is transferred from the mind of the teacher, or the page of the textbook, to the mind of the student. Instead, it is now commonly accepted that knowledge is a product
of ways in which the student’s mind is engaged by the activities and resources of the classroom.

Constructivism has become especially popular in science education, where research on children’s explanations of natural phenomena expanded rapidly in the 1980’s. Recent research studies on teaching and learning science education (Carey, 1986; Driver, Asoko, Leach, and Scott 1994) have increasingly been based on the view that student construct their own knowledge as they engage in the process of interpreting and making sense of their classroom experience. Learning is seen as the conceptual restructuring that results from this cognitive processing.

As a consequence of this view, it is no longer to make the assumptions that there can be direct link between teaching and learning. The way that tasks are structured, the questions that teachers ask, the examples that students practice, can only have indirect effects on student learning (Hiebert and Wearne, 1993). As students encounter new experiences, their minds construct representations of those experiences that are structured by their own previous knowledge and beliefs. These individually constructed representations interact with each other in the production of new knowledge and belief.

Although the basic principle in constructivism is that each individual constructs a personal meaning from information and experience, this does not mean that all constructions are equally valid or useful, nor that mentor have no role in learning. Duit (1995) reminds us that the issue in teaching is one of balance between self-development and guidance. That is the essence of Vygotsky’s (1978) much cited notion of a zone of proximal development. Vygotsky noted that children could, with the help of a more knowledgeable person, solve problems that they cannot do on their own. The tutor does not solve the problem for them, but guides their thinking. For guidance to be successful, however, the learner must already have relevant knowledge on which the thinking can draw. In new learning, which can be regarded as a form of problem solving, the guidance must help the learner to relate the new information to old. This
notion of Vygotsky's is consistent with other writing on the construction of meaning, for example by Ausubel (1968) and Wittrock (1990)

Although the learner is central to the learning process, constructivism encourages collaboration among the learner groups as well as with teachers. Therefore, learning, according to constructivist approach is the outcome of the complex interplay among learner's existing knowledge, the social context, and the problem to be solved. Instruction, then, refers to providing learners with a collaborative situation in which they have both the means and the opportunity to construct new and situationally – specific understanding by assembling prior knowledge from diverse sources (Ertmer and Newby, 1993, p.63)

1.4.3.0 Future Research Trends in Science Teaching

From the above discussions the following trends in science teaching at school level appear to be perceptible:

i. Experimental study on effect of teaching methods having a sound theoretical base on different context like Pre-Achievement levels of the pupils, mental ability of the students etceteras.

ii. Effectiveness of the methods on different types of students like gifted, educationally handicapped, mentally handicapped, low achievers and high achievers.

iii. Effectiveness of methods on different criterion measures such as Scientific Attitude, Science Process Skills, Scientific Creativity, Scientific Temper and Problem Solving Ability.

iv. Comparative study on the effectiveness of the methods with respect to different context, types of students and different criterion measure and teaching process associated with each method in different context.

1.5.0.0. Need for the Study

From the discussion above as well as from the review of related literature presented in Chapter Two the following observations can be made:
i. Research on teaching methods is essential in order to bring out the desired outcomes of education.

ii. Research on teaching should study the difference in how the content is taught and the pupils to whom it was taught and for what purposes it is taught.

iii. Research studies on teaching strategies should be presage-process, context-process, process-product, and presage-process-product and presage-context-product studies.

iv. The status of science education in general and science instruction in particular is not at a satisfactory level in our country.

v. While teaching science, more emphasis should be on organic and meaningful learning than mechanical learning and more and more emphasis on the improvement of thinking than the attainment of narrowly conceived specific understanding and skills. Therefore, a swing towards self-study, self-understanding and self-education among students rather than authoritarian or dominated teaching learning process by teacher.

vi. Research studies on teaching science at the primary level have been very meager. Thus, there is scope for studying the efficiency of teaching strategies at the primary level for learners with special educational needs.

vii. Learning is the conceptual restructuring that result from the cognitive processing of new experiences. Therefore, Pre-Achievement levels of the pupils are an important variable to be researched.

The above points led the investigator to try out Teacher Demonstration, Guided Discovery and Cooperative Learning Methods of Teaching Science on pupils of Standard Six with different Pre-Achievement Levels and to find out their effects on Achievement in Science, Basic Science Process Skills and Scientific Attitude. A paradigmatic perspective of the present study is given in the next Section.
1.6.0.0 A PARADIGMATIC PERSPECTIVE OF THE PRESENT RESEARCH

Traverse (1973, p.50) states that in designing a research, the investigator's paradigm, that is in the words of Kuhn (1962), "his basic assumptions and way of conceptualizing the area of inquiry" determines not only what questions will be asked, but also the kinds of data that will be considered relevant and how the data will be gathered, analyzed, interpreted and related to theoretical concepts. It is therefore desirable to make explicit the underlying paradigms and associated theories on which the research is based. It is useful to view the present research from a teaching perspective or paradigm.

However, Social Sciences and Education are not necessarily dominated by a single school of thought. Observing this absence of a single dominant paradigm in Social Sciences, Kuhn considered Social Sciences and Education to be in a state of pre-paradigmatic retardation. But Merton (1965, p.51) argues for the superiority of a set of competing paradigms over the hegemony of a single school of thought. He asserts that theoretical pluralism encourages the development of a variety of research strategies rather than premature closure of investigator consistent with problematic of a single paradigm. He advocates the virtues of "a discipline eclecticism".

It is very clear from the above view points and discussion that research on teaching is as complex as the subject it investigates. Thus, the researcher should find in it not only a wide variety of different conceptual schemes for expressing the behaviours of teachers and pupils but also many different types of variables that are presumed to bear relationships to the teaching process. If one has to consider this research in an economical and thoughtful manner, one must find a way of assembling concepts and information. Hence, the researcher tried to identify the paradigm that can put this present study in a proper perspective and one such paradigm was found to achieve this end. The following is a discussion of this paradigm.
1.6.1.0 Dunkin and Biddle Model for Research on Teaching

The Dunkin and Biddle model for research on teaching, based on an earlier formulation by Mitzel (1960). It is a comprehensive theoretical matrix, which provides a working vocabulary to describe what a researcher is studying and how he will go about it.

Dunking and Biddle (1974) posited the following four classes of variables.

1. **Presage Variables**: Concern the characteristics of teachers that may be examined for their effects in teaching process. These are the teacher’s experiences, training and other perspectives that influence teaching behaviour.

2. **Context Variables**: Concern the conditions to which the teacher must adjust characteristics of the environment. Variables like pupil formative experience, pupil properties, school and community contexts, classroom contexts etceteras are included in this category.

3. **Process Variables**: Concern with the actual activities of classroom teaching. Observable behaviours of teachers and pupils are included in this category.

4. **Product Variables**: Concern the outcomes of teaching, those changes that come about in the pupils as a result of their involvement in classroom activities with teachers and other pupils. These include immediate and long-term effects of teaching on pupil’s growth, intellectual, social and emotional. A diagrammatic representation of the Dunkin and Biddle model is given in Fig. 1.1.
Fig. 1.1. A Model for the Study of Classroom Teaching
The present research aims to study in depth the effects Teacher Demonstration, Guided Discovery and Cooperative Learning Methods of Teaching Science on Achievement in Science, Basic Science Process Skills and Scientific Attitude of pupils with different Levels of Pre-Achievement in Science, study the interaction patterns associated to these three methods and also methods with respect to achievement levels. Thus, from the perspective of this model the present study could be viewed from four dimensions of the variables involved in the teaching learning process.

1. **Presage-Context-Product**: Relationship between Methods, Levels of Pre-Achievement of the pupils in Science and Achievement in Science, Basic Science Process Skills and Scientific Attitude.

2. **Presage-Process**: Relationship between Method and Interaction Patterns

3. **Context-Process**: Relationship between pupils Levels of Pre-Achievement in Science and the Interaction Patterns of the Method


### 1.7.0.0 STATEMENT OF THE PROBLEM:

‘A study of the effects of different Methods of Teaching Science on Achievement in terms of Knowledge, Understanding and Application, Objectives and its retention, Basic Science Process Skills and Scientific Attitude of Standard Six pupils with different Achievement Levels.

### 1.8.0.0 OBJECTIVES OF THE STUDY

As discussed under Section 1.6.1.0., the present study can be viewed from five dimensions of the variables involved in the teaching-learning process. The investigator has also classified the objectives of the study under the same four dimensions as given below.
1.8.1.0 Objectives Related to Presage-Context-Product

i. To study the effect of Methods, Levels of Pre-Achievement and their interaction on Achievement of Knowledge, Understanding and Application objectives separately by taking Intelligence as covariance.

ii. To study the effect of Methods, Levels of Pre-Achievement and their interaction on Total Achievement, Scientific Attitude and Basic Science Process Skills separately by taking Intelligence as covariate.

iii. To study the effect of Methods, Levels of Pre-Achievement and their interaction on retention of Knowledge, Understanding and Application Objectives and Total Achievement separately by taking Intelligence as covariate.

1.8.2.0 Objectives Related to Presage-Process

To study and compare the teaching processes in terms of interaction patterns associated with the Teacher Demonstration Guided Discovery and Cooperative Learning Methods of Teaching Science.

1.8.3.0 Objectives Related to Context-Process

To study and compare variation in interaction patterns due to change in prior achievement levels of pupils with respect to Teacher Demonstration Guided Discovery and Cooperative Learning Methods of Teaching Science.

1.8.4.0 Objective related to Process-Product

To explain the relationships between significant differences in Achievement, scientific attitude and Basic Science Process Skills in terms of differences in teaching process.
1.9.0.0 HYPOTHESES

The following three hypotheses were formulated for the present study

1. There is no significant effect of Methods, Levels of Pre-Achievement and their interaction on Achievement of Knowledge Understanding and Application Objectives separately by taking Intelligence as covariate.

2. There is no significant effect of Methods, Levels of Pre-Achievement and their interaction and Total Achievement, Scientific Attitude and Basic Science Process Skills separately by taking Intelligence as covariate.

3. There is no significant effect of Methods, Levels of Pre-Achievement and their interaction on retention of Knowledge, Understanding and Application Objectives and Total Achievement separately by taking Intelligence as covariate.

1.10.0.0 OPERATIONAL DEFINITIONS

Co-operative Learning Method

Cooperative Learning refers to a family of small group instructional practices in which, the group work is carefully prepared, planned and monitored by the teacher so that students work together to maximize their own and each other's learning. In the present investigation the Cooperative Learning Method was referred to as the method of teaching in which the teacher provided the various tasks based on the content selected for the study, which were planned and designed in a definite sequence to attain the objective of the lesson to groups of four pupils of the same age and achievement level. Communication of the group goal and task structure, monitoring of group work and testing of individual learning were done by the teacher.

The sequence of moves followed were Communication of the Group Goal (CGG) → Communication of the Task Structure (CTS) → Pupil-Pupil Interaction (PPI) → Monitoring and Intervention by the Teacher (MIT) → Testing of Individual Learning (TIL)
Guided Discovery Method

Guided Discovery Method is a method of teaching in which the pupils will be provided with guidance/directions in the form or series of examples or cue questions step by step by the teacher so as to help the pupils to discover the concepts/principles to be learnt. In the present investigation the Guided Discovery Method referred to the method of teaching in which, the teacher provided the basic elements of the lesson in the form of carefully sequenced examples following the inductive approach, highlighting the features of special relevance, leading question and hints, and made each student to draw the generalization and discover the concepts/principles.

The sequence of moves followed were, Clarification of the Concept (CC) → Generalization of Concept (GC) → Examples from the Pupil (EP) → Application of the Concept (AC).

Teacher Demonstration Method

The Teacher Demonstration Method is a method of teaching in which the teacher gives an oral presentation of the subject matter while demonstrating with certain devices. In the present study the Teacher Demonstration Method was referred to as the method of teaching in which the teacher stated the concepts/principles and clarified them through oral presentation of the subject matter while demonstrating with certain devices such as experiments / models / charts specimens.

The sequence of moves followed were the Statement of the Concept by the Teacher (SCT) → Clarification of the Concept through Demonstration (CCD) → Summary of the Demonstration by the Pupil (SDP) → Application of the Concept (AC).

Achievement in Science

Learning attained in the form of Knowledge, Understanding and Application by the sample related to the units of content in science of Standard Six which was used for treatment in the present study was considered as
Achievement. It was measured through a specially prepared Post-Achievement Test by the Investigator.

**Scientific Attitude**

Scientific Attitude is the mental attitude characterized by willingness to search for truth, without prejudices, to change one's opinion on the basis of new evidence, to seek the cause and effect relationship and to discriminate between fact and theory Good (1945, p.37).

In the present study Scientific Attitude was defined as the mental attitude characterized by commitment of the value of rationality, to seek cause-effect relationship, acceptance of criticalness, desire for completeness of knowledge, seeking to find out 'how' and 'why' of observed phenomena, willingness to search for truth, aversion to superstition, objectivity of intellectual beliefs, and to discriminate between fact and theory. It was measured using the Scientific Attitude Scale (SAS) constructed by the Investigator.

**Basic Science Process Skills**

Science Process Skills are a set of broadly transferable abilities, appropriate to many science disciples and reflective of the true behaviour of scientists. [Science – A process Approach (SAPA)]. SAPA divided the process skills into two types, basic and integrated. The Basic Science Process Skills are the basic ways of thinking by the scientist in discovering and ordering knowledge. These skills provide a foundation for learning the more complex integrated skills. The Basic Science Processes are observing, classifying, communicating, measuring using space/time relations, using numbers, inferring and predicting. The Integrated Science Process Skills are controlling variables, interpreting data, formulating hypothesis, defining operationally and experimenting. The Basic Science Process Skills considered for the present study were:

- a. Observation
- b. Inference
- c. Classification
- d. Measurement
- e. Communication
- f. Prediction
Observation

In the present study the Process Skill of Observation was considered as the pupils’ empirical experiences realized through their senses and expressed in the form of statement of facts and propositions which was measured through the Test on Basic Process Skills.

Inferences

The Process Skill of Inferences was an ability to make judgement about non-observable properties of an object or an event based on the observable properties of the object or event based on the assumption of continuity, which was measured through a Test on Basic Process Skills.

Classification

The Process Skill of Classification was referred to as the ability of the pupils to classify and seriate the objects according to the given criteria based on the observations made on the given data, which was measured through the Test on Basic Process Skills.

Measurement

The Process Skill of Measurement was an ability to measure the given objects using the unit of measure prescribed, with accuracy, which was measured through the Test on Basic Process Skills.

Communication

The Process Skill of Communication was an ability to report and explain the observed phenomena with accuracy, completeness and conciseness, which were measured through the Test on Basic Process Skills.

Skill of Prediction

The Process Skill of Prediction was an ability to forecast future observations based on extensive and careful observation of the given data, which was measured through the Test on Basic Process Skills.
Achievement Levels

The Achievement Levels were referred to as the Pre-Achievement levels of the sample of the study. Pre-Achievement was considered as the status attained by the sample with respect to learning attained in the form of Knowledge, Understanding and Application related to the content in science which was an essential pre-requisite to learn the units of content in science of Standard Six which was used for treatment in the present study. It was measured through the specially prepared Pre-Achievement Test by the Investigator.

The two Levels of Pre-Achievement considered in the present study were low Pre-achievement level and high Pre-Achievement Level and were termed as ‘high achievers’ and ‘low achievers’ respectively.

High Achievers

The pupils whose scores on the Pre-Achievement Test were at Q₃ and above.

Low Achievers

The pupils whose scores on the Pre-Achievement Test were at Q₁ and below.

Pupils of Standard Six

Pupils of Standard Six were the ones studying in the selected three Government Higher Primary Schools situated in rural areas of Dakshina Kannada District

Knowledge Objective

The Knowledge Objective emphasizes most the psychological processes of remembering. In the present study, the Knowledge Objective was referred to those behaviours or test situations, which emphasize remembering either by recognition or recall of concepts, principles, methods and phenomena. It was measured through a specially prepared Post-Achievement Test.

Understanding Objective

The Understanding Objective was those behaviours or responses which represent an understanding of the literal message contained in communication and
make use of the material or idea being communicated without necessarily relating it to other material or seeing its fullest implications. It was measured through the specially constructed Post-Achievement Test.

**Application Objective**

The Application Objective was the behaviours or responses which represent the use of concepts / principles/ procedures / methods correctly in a given appropriate situation in which no mode of solution is specified, which was measured through a specially prepared Post-Achievement Test.

**1.11.0.0 SCOPE AND LIMITATIONS OF THE STUDY**

i. This study was limited to only students selected from three Government Higher Primary Schools of a rural area from Dakshina Kannada District of Karnataka State.

ii. Most of the students were from middle and lower middle classes of the society.

iii. There were sixteen students in each sub-group. Thus, the total sample was limited to ninety-six.

iv. The teaching units were selected from the Science textbook of Standard Six of Karnataka State.

v. The low achievers and high achievers of Standard Six were taught through Teacher Demonstration, Guided Discovery and Cooperative Learning Methods of Teaching Science. Thus, the study was limited to low achievers and high achievers of Standard Six.

vi. Sixteen lessons on two selected units, that is, ‘The Changes Around Us’ and ‘Motion, Force and Machines’ were taught for sixteen school periods to each of the six subgroups. Thus, the total treatment period was limited to ninety-six school periods.

vii. The study was limited to find the comparative effectiveness of the Teacher Demonstration, Guided Discovery and Cooperative Learning Methods of
Teaching Science on pupil’s Achievement in Science, Basic Science Process Skills and Scientific Attitude.

viii. In the present study the effects of Teacher Demonstration, Guided Discovery and Cooperative Learning Methods of Teaching Science was limited to the six Basic Science Process Skills as defined operationally in the Section 1.9.0.0.

ix. The study was limited to only pupils Achievement in Knowledge, Understanding and Application Objectives under cognitive domain.

x. In the present study the teaching –learning process of group of students and not of individuals students was studied.

1.12.0.0 EPILOGUE

In the light of the points discussed in this Chapter the theory and research studies related to Teaching Methods, with special reference to Teacher Demonstration, Guided Discovery and Cooperative Learning would be reviewed in the next Chapter. This will provide a theoretical and empirical base for the design and implementation of the study.