Chapter II

REVIEW OF RELATED STUDIES
<table>
<thead>
<tr>
<th>S.No.</th>
<th>Contents</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CHAPTER II</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>REVIEW OF RELATED STUDIES</td>
<td>27</td>
</tr>
<tr>
<td>2.1</td>
<td>INTRODUCTION</td>
<td>27</td>
</tr>
<tr>
<td>2.1</td>
<td>STUDIES DONE IN INDIA</td>
<td>28</td>
</tr>
<tr>
<td>2.1.1</td>
<td>STUDIES MADE ON THE STATUS OF SCIENCE EDUCATION IN INDIA</td>
<td>28</td>
</tr>
<tr>
<td>2.1.2</td>
<td>STUDIES MADE ON THE ANALYSIS OF DIFFICULTIES IN TEACHING AND LEARNING SCIENCE</td>
<td>33</td>
</tr>
<tr>
<td>2.1.3</td>
<td>STUDIES MADE ON THE IMPACT OF VARIABLES IN TEACHING AND LEARNING SCIENCE</td>
<td>35</td>
</tr>
<tr>
<td>2.1.4</td>
<td>STUDIES MADE ON THE IMPACT OF INNOVATIVE INSTRUCTIONAL STRATEGIES IN TEACHING SCIENCE</td>
<td>37</td>
</tr>
<tr>
<td>2.2</td>
<td>STUDIES DONE ABROAD</td>
<td>47</td>
</tr>
<tr>
<td>2.2.1</td>
<td>STUDIES MADE ON THE IMPACT OF VARIABLES IN TEACHING AND LEARNING SCIENCE</td>
<td>47</td>
</tr>
<tr>
<td>2.2.2</td>
<td>STUDIES MADE ON THE IMPACT OF INNOVATIVE INSTRUCTIONAL STRATEGIES IN TEACHING SCIENCE</td>
<td>50</td>
</tr>
<tr>
<td>2.3</td>
<td>CRITICAL REVIEW OF THE STUDIES CITED</td>
<td>65</td>
</tr>
</tbody>
</table>
CHAPTER II

REVIEW OF RELATED STUDIES

2.1 INTRODUCTION

The survey of related studies implies locating, studying and evaluating report of relevant researches, study of published articles, going through related portions of encyclopedias and research abstracts. This summary provides evidence that the researcher is familiar with what is already known and what is still unknown and not attempted. Effective research is based upon past knowledge and this helps to eliminate the duplication of what has been done.

It facilitates the investigator to identify research gaps if any, in order to create new ground in research. It helps to gather up-to-date information about the area in which the investigator intends to study. It also gives valuable guidance in solving the problem, recognizing its significance and selecting data gathering devices, appropriate study design, source of data and suitable analysis of data. The methodology of the previous researches may also be compared with that of the present study and thus helps in locating comparative data useful in the interpretation of results.

Without review of related literature one cannot proceed in research with firm ground and justification.

Hence a review of previous studies in the areas related to the present study is attempted and presented in this chapter. The investigator made a review of related studies under the following classifications:

1. Studies done in India:
   1. Studies made on the status of science education in India.
2. Studies made on the analysis of difficulties in teaching and learning science.

3. Studies made on the impact of variables in teaching science.

4. Studies made on methods of teaching science.

2. Studies done Abroad:

1. Studies made on the impact of variables in teaching science.

2. Studies made on methods of teaching science.

2.1 STUDIES DONE IN INDIA

2.1.1 STUDIES MADE ON THE STATUS OF SCIENCE EDUCATION IN INDIA

Krishnan (1981) made a comparative study of the secondary schools science curricula of Kerala and Tamil Nadu. He developed a comprehensive evaluative criterion for assessing the secondary school science curricula and to compare the secondary schools science curricula of the states of Kerala and Tamil Nadu in terms of the developed curricula. The analysis was attempted in five dimensions namely; functional-utilitarian, behavioral-developmental, conceptual-disciplinary, pedagogical-curricular and methodological-instructional. The science text books prescribed for standards V through X were analyzed by 20 specialists.

He found that the curricula of both the states were weak in the dimensions of "methodological-instructional". The curriculum of Tamil Nadu was found to be additionally weak in the provision for understanding of science based social functions, provision for accept forms of curricular organization, representation to important scientific movements, basic laboratory work and comprehensive evaluation of learning outcome and provision of text books and audio-visual materials. He also found that the two curricula did not give adequate
importance to self study or practical work. They were found to be too rigid to provide meaningful experiences outside the class room.

*Ashraf, Mohamed* (1988) made a case study of selected Delhi schools with special reference to innovative classroom practices.

Major objectives of the study were:

1. To study some schools in Delhi sociologically with a view to understanding the sociological context of the innovations introduced in their classrooms.
2. To study the ongoing as well as the left-over innovative practices in their classrooms.
3. To study the impact of those innovative classroom practices on students, teachers, schools and the community and
4. To make generalization about the factors facilitating and obstructing innovations in schools.

Thirty-two senior secondary schools in Delhi were randomly taken in the sample. Thirty-five case studies of educational innovations in these schools were prepared. The tools used included a questionnaire, an Interview Schedule, and an Observation Guide. The data collected were treated using qualitative methods.

Major findings of the study were:

1. The sex of the students and teachers was an important factor in the success or failure of an innovative classroom practice.
2. The planning of an innovation counted a lot in its smooth functioning.
3. Shortage of time or non-availability of time was a very serious hurdle in the success of an innovative activity.
4. The absence of funds had a direct and adverse impact on the smooth functioning of an innovation.
5. There were several hurdles in the successful completion of innovations, e.g. shortage of proper space, lack of competition, too much emphasis on formal examinations, large number of students, shortage of equipment, lack of coordination among the staff, lack of properly trained staff, lack of publication facilities and lack of parental cooperation.

*Sundararajan* (1988) evaluated the teaching of Biology at higher secondary stage in Tamil Nadu.

Major objectives of the study were:

1. To determine the extent of awareness as well as the realization of the objectives of teaching Biology on the part of the teachers of Biology at the higher secondary stage,

2. To find out the teaching strategies employed, identify the teaching model used, if any, and also examine the problems faced by them in their teaching on Biology,

3. To determine the adequacy or otherwise of the practical activities organized for the +2 stage biology students,

4. To evaluate the physical facilities available in schools for the teaching of Biology.

The sample of the study comprised 1,000 higher secondary students covering 520 boys and 480 girls and 480 urban students and 520 rural students. These students were selected from six districts of South Arcot from 105 higher secondary schools by the random selection method. The sample also included 278 biology teachers and 60 experts. The tools used in the study included a Questionnaire, a Perception Scale, an Inventory of Physical Facilities, an Opinionnaire, an Achievement Test and an Attitude Scale. The collected data were analysed with means, percentages, product-moment correlation and chi-square.

Major findings of the study were:

1. Hierarchy of the objective related to the teacher gave more importance to the knowledge, followed by understanding, application and skills,
2. Generally teachers were found to follow only the expository type of teaching strategies in their teaching of biology. They did not encourage discussion among the students and other student-centered teaching techniques.

3. The biology laboratories were in a bad shape. A full complement of chemicals and equipment was not found in many schools and they did not have essential teaching aids, too.


Major objectives of the study were:

1. To identify the deficiencies and inadequacies in the existing laboratory facilities.
2. To ascertain if the required number of teacher demonstrations and student practical are performed.
3. To examine if the laboratory is adequately utilized.
4. To see if the schools are providing separate laboratories.
5. To see if the equipment in the laboratory is adequate.
6. To find out if there is any provision for improvisation of science equipment.

A multi-stage stratified sampling method was used in drawing the sample of schools for the study. At the first stage, the state was divided into different homogeneous regions (strata) on the basis of geographical, political, and socio-economic factors. Then from each stratum, one or two districts were selected at random. At the second stage, the selected districts were divided into rural/urban and then the schools were stratified into different managements. Finally, from each selected district, a random sample of 10% secondary schools and 15% higher secondary schools were selected so that all managements and rural and urban areas were represented. The tool used in the study also included a questionnaire.
Major findings of the study were:

(1) It was observed that in Maharashtra, almost all schools - 96.7% in urban areas and 92% in rural areas - had science laboratories. (2) Out of 70 higher secondary schools which responded, in urban areas, 94.7% were having science laboratories as against 71.9% in the rural areas. (3) Out of the 105 secondary schools which had science laboratories, only 26 had separate laboratories, i.e. hardly 25%. In the urban areas, the position was better than rural areas. (4) Out of 58 secondary schools in rural areas, about 60% used one to three hours per week for teacher demonstrations, 20% used four to five hours time and remaining 40% used seven hours and more for teacher demonstrations. In urban schools, the position was slightly better. About 40% schools used laboratories for one to three hours, another 20% used it for four to six hours and the remaining used it for seven hours and above. (5) Time devoted to science practical differed in urban and rural schools. The position in urban schools was worse than that in rural areas. (7) In Rajasthan's secondary school 92.10% rural schools had laboratories as compared to 83.3% urban schools. In the case of higher secondary schools, 94.60% rural schools had these facilities as compared to 90.90% in urban schools. (8) The facility of separate laboratories was available in 91.9% urban schools as compared to 85.7% rural schools. (9) About 50% of school students had the facility of performing experiments individually in physics, 74.74% in chemistry and 81.72% in biology. (10) For performing science practicals, in case of private aided and private unaided schools, only 80% and 66.7% schools respectively allotted adequate time for performing science practicals. (11) Only 27.8% of government schools had the facility for repairing and improving of science equipment. In rural areas this facility was available in 14.8% secondary schools and in urban, 66.7% secondary schools.

_Nayar, Ajitha and Pushpam_ (2000) made a study on the willingness of secondary school teachers of Biology to use teaching aids. The study revealed that secondary school teachers had low willingness to use teaching aids. Low level of willingness was exhibited by
majority of the secondary school biology teachers irrespective of the management and locale of the school. It was concluded therefore that, teachers are not willing to make their teaching interesting and are satisfied by the traditional chalk-and-talk method. It was interesting to note that less experienced teachers displayed a significantly higher mean than the more experienced teachers. It was also concluded that new teachers are still influenced by the training received as part of their teacher education course. They observed that the high level of willingness exhibited was a reflection of the teachers’ flexible attitude and dynamic approach to teaching.

2.1.2 STUDIES MADE ON THE ANALYSIS OF DIFFICULTIES IN TEACHING AND LEARNING SCIENCE

_Gadkari_ (1982) constructed a diagnostic test in general science for the students studying in standard IV of Marathi Medium schools of Kalyan, DombiVali, and Thane Region. He identified the pupils who were deficient in general science with reference to specific units. He discovered the areas of difficulty and prepared a remedial teaching programme based on the analysis of errors committed by the pupils and measured the outcomes of the remedial teaching programme.

The test was administered in two groups. Five tests of the first group were administered to 1289 students of standard IV. The Six tests of the second group were administered to 1335 students of standard IV. The remedial teaching test was administered to 165 students who failed in the annual examination in general science.

Major findings of the study were:

1. Students of standard IV had developed wrong concepts in the subject of science.
2. The wrong concepts were identified with the help of diagnostic test in science which was constructed by the investigator. Diagnostic test helped to find out the nature of errors on the basis of which the remedial teaching programme was framed for each unit.
3. The effectiveness of the remedial teaching programme was evaluated and it was found that the programme helped to improve the teaching learning process and thereby rectified the wrong concepts formed by students.

Singhal (1983) made a study on physics education using non-formal methods. He identified the academic problems of science students and teachers at the higher secondary stage and first year of colleges. He conducted an action oriented programme according to the requirements of the respondents. In order to identify the academic problems a questionnaire was circulated among physicists and educationists working in higher secondary schools, colleges, universities and research institutions mostly in Rajasthan and also in a few places outside the state. After identifying the problems a number of programmes were organized to meet the requirements of the students and teachers. The programmes included competitions into disciplinary talks, Physics through thought questions, short-duration courses, library use and evaluation of the courses.

The major conclusions of the study were:

1. Students did not read beyond the syllabus and did not inculcate the habit of understanding the basic concepts of Physics.
2. Science students were found very weak in numerical work.
3. Expressions were very weak as they did not prepare their own notes.
4. Thought questions created interest in physics and a larger number of respondents appreciated this effect.
5. Short-duration courses organized for teachers and the cyclostyled materials prepared by them were found useful by the teachers.
6. Special classes and inter-disciplinary talks were found useful.
Verma (1986) constructed a diagnostic test in chemistry and prepared remedial measures. He also studied few typical cases. The sample comprised 250 class IX students following the All India Secondary School Certificate Examination Scheme, 50 teachers and 250 parents of the students. Four cases of high intelligent and low achievement and vice versa were selected for case study. The descriptive survey method was applied for the location of errors. The efficiency of remedial instructions was tested by the experimental method and case method was used for a through study of certain cases. An open ended questionnaire, structured scales for students, teachers and parents, and an observation schedule for class observation were used for identification of reasons for errors. Achievement test and intelligent test were used to identify the efficiency of remedial measures.

The major findings of the study were:

1. A hierarchy of reasons for errors separately supplied by students, teachers and parents was established on the basis of weighted scores allotted to them
2. The effect of remedial measures on the experimental group even at different levels of intelligent was significant at 0.01 levels.

2.1.3 STUDIES MADE ON THE IMPACT OF VARIABLES IN TEACHING AND LEARNING SCIENCE

Nathan, Raventhra (1983) compared the impact of medium of instructions on the science achievement, science interest and mental health status of secondary school students. Major objectives of the study were:

1. To compare the science achievement, science interest and mental health status of secondary school pupils in the English medium and Malayalam medium classes.
2. To determine the relationship between the medium of instruction and science achievement, science interest and mental health for the total sample and sub-samples.
The study had a sample of 890 secondary school students. He found that the science achievement, science interest, and mental health status of English medium students were higher than those of Malayalam medium classes. The study suggested that the choice of medium of instruction for science should be made on the basis of individual assessment of pupils.

Darchingpui (1989) examined the relationships among variables such as achievement in science, attitudes toward science and problem-solving ability under certain conditions such as location, socio-economic status, parental education, occupation and typology of school among secondary school children.

The objectives of the study were:

(i) to study the science achievement, attitude towards science and problem-solving ability of high school students, (ii) to find the interrelationships of science achievement, attitude towards science vis-à-vis problem-solving ability, and (iii) to examine the relative effect of sex, socio-economic status, parental education, parental occupation, family facility, and type of school on science teachers. The scientific temper scale devised on the Likert method of summated ratings was used to collect the data.

Major findings were as follows:

(1) Significant differences in scientific temper were noticed between male science teachers and male non-science teachers; female teachers and male teachers, rural girls and urban girls, urban boys and urban girls and finally, male science students and female science students. (2) No significant differences appeared between female science and non-science teachers as well as science students and non-science students.

Joshi (1989) studied the acquisition of chemistry concepts as related to the variables of educational environment.
The major objectives were:

(i) To find out the relationship between the variables of educational environment (related to student, teacher, home and school) and the acquisition of chemistry concepts, and (ii) to find out how far these variables contribute to the prediction of achievement on the chemistry concepts test.

The study samples varied within the context of various stages of standardization and for the final study, 470 Grade X pupils were drawn through stratified random sampling from 15 English medium schools in Dehradun and Mussoorie in U.P. affiliated to the Central Board of Secondary Education (CBSE). Teacher and School Proforma, and Chemistry concept Test and School Characteristics Index were prepared and standardized by the investigator. Raven’s Standard Progressive Matrices, Kuppuswamy’s Socio-economic Status Scale, and Teacher Attitude Scale by Grewal, were the tools used for the collection of data. Data analysis for the final study involved descriptive statistics, correlation, factor analysis and multiple regression analysis.

Major findings of the study were:

(1) Intelligence and socio-economic status of the parents were significantly as well as positively correlated with acquisition of chemistry concepts. (2) Variables related to teachers (length of teaching experience and teacher attitude index, etc.) had a significant bearing on the performance of students on the chemistry concept test.

2.1.4 STUDIES MADE ON THE IMPACT OF INNOVATIVE INSTRUCTIONAL STRATEGIES IN TEACHING SCIENCE

Vardhini (1983) developed a multimedia instructional strategy for teaching science (Physics and Chemistry) at secondary level. The instructional strategies were validated on a single group of 45 students of class VIII of an English Medium school of Baroda city.
inputs of the strategy were introduction, lecture, discussion sequence, discussion, guided discovery, audio-visual and biographical accounts, summaries, diagrams, exercises and assignment, criterion test and feedback. The experiment was conducted for one academic year to cover 19 units of the subjects chosen for the study.

The major findings of the study were:

1. Visual projections with teacher explanation and those with taped commentary were equally effective in terms of achievement.
2. Almost all the units indicated average or high level performances on the total tests.

The study also suggested that a systematically validated multimedia strategy can be implemented at school level with suitable cost and time consonant.

_Dighal_ (1985) made a study on improved method of teaching Biological Sciences in Schools of Tirpura and West Bengal.

The major objectives of the study of the study were:

1. To explore how to make life Science Teaching lively realistic and interesting to the students
2. To attempt scientifically the improvement of the present methods.
3. To remove the drudgery in the teaching of Biological Science.
4. To prepare a better method which was an extraction from the existing methods and more scientific and refined.

The sample consisted of 500 students of class IX. He found that two or three methods when combined formed to be more effective. He suggested that this combination could be made based on the needs of the teacher. Preparation of charts and models, collection of specimens through local excursions, organization of Science exhibitions by the students, arrangement of film shows by the school, and orientation programmes for life science teachers brought better results.
Agnihotri (1987) studied the influence of some selected methods of teaching physics on the achievement in physics of class X students. The investigator used the traditional method, lecture-demonstration method, programmed instruction method and assignment cum discussion method. Investigator selected 520 grade X students from 10 schools. He found that out of the selected four methods, the method of teaching physics systematically designed by the investigator is the most effective method.

Lambhate (1987) developed instructional material for teachers teaching science to class VI in rural areas of Madhya Pradesh. He made a survey of the rural areas in which the schools were situated; analyzed the content of the science textbook prescribed for class VI; identified the relevant village based material activities and situations for the teaching of science in the classroom; developed written instructional material, incorporated it with necessary aids and developed a science teaching competence scale to find out the effectiveness of the instructional material. A random sample of 24 teachers was selected for the study.

He found that the use of instructional material improved the performance of the teachers. The teachers of the experimental group performed better than those of the control group on (i) selection and organization of contents, (ii) use of proper scientific technology, teaching aids and experimentation and (iii) maintaining the classroom discipline by sustaining the attention of students with the help of the instructional material. But the materials developed did not equip the teachers to enable their pupils to think critically.

A process approach to science teaching acquires prominence which shifts the focus of teaching-learning process to the acquisition of scientific capabilities rather than the transmission of scientific information mechanically. This study of Grewal, Avinash (1988) focuses on the need to organize learning experiences in such a manner where learners are exposed to the basic and integrated skills required in dealing with the scientific knowledge.
The investigator developed and tested the efficacy of self learning process-based material for the development of integrated processes of science such as classifying, inferring, interpreting, predicting, hypothesis making and testing.

The sample of the study initially comprised 390 higher secondary students from four higher secondary schools of Bihar City, which was reduced finally to 77. Collected data were treated with mean, standard deviation, ‘t’ test and product-moment correlation.

The study revealed that the processes of prediction and interpretation were hardly found in teaching and the more commonly used processes were inferring and classifying.

*Mohapatra* (1989) focused on studying the pupils’ popular preconceived concepts about scientific events related to their day-to-day life observations and the implications of the same for organizing suitable teaching-learning strategies through utilization of their experiences.

The major objectives were:

(i) To study the review of related studies on the origin of scientific concepts formation in the minds of children, (ii) to discuss some of the major characteristics of different alternative concepts in the minds of children, (iii) to identify the role of the teacher and the learner in the teaching-learning process in developing and modifying scientific concepts, and (iv) to determine the implications of various types of concepts development process in the teaching-learning situations.

The present study is based on review of related literature regarding the origin of scientific concept formation in the minds of children. The researcher has tried to identify major characteristics of different alternative concepts in the minds of children and related it to the teaching-learning situation.

Major findings of the study were:

(1) It was observed that children made a great deal of conceptualization on the basis of their observation of day-to-day happenings in the environment and in home situations. In this process
they formulated alternative concepts about things, objects and events. (2) The science teacher had an important role in helping the child to develop proper concepts about objects and events by utilizing children’s personal experiences with the rational thinking process.

Ramani (1989) compared the outcomes of the teaching of some selected units on electronics by different strategies at the higher secondary level.

The Objectives were:

(i) To develop different lesson plans based on the four methods of teaching science, and (ii) to study the effectiveness of different methods of teaching science. The sample of the study comprised 40 students of Standard XI at the Government Higher Secondary School, Sholavandan. The Solomon four-group design was used. The sample was divided into four groups which were exposed to four methods of teaching by rotation. Four different lesson plans, based on the four methods of teaching, were developed and used. At the end of the experiment, the achievement of the four groups were measured. The ANOVA test was used for statistical analysis.

The major findings were:

1. Laboratory work was more effective than the demonstration method.

2. Group-discussion was more effective than demonstration.

3. Demonstration was more effective than the lecture method.

Goel and Agbebi (1990) attempted to compare the relative effectiveness of the individualized method and the lecture-demonstration method of laboratory instruction on student acquisition of psychomotor and related cognitive skills when the specific behavioral objectives of five physics experiment in the subject area of light were pre-disclosed to students before instruction.
This study compared the relative effectiveness of the individualized method and lecture-demonstration method on acquisition of psychomotor and related cognitive skills among female pupils.

Forty-four female Nigerian students studying in Class V whose age ranged from 15 years constituted the sample of the study. The data were collected with the help of an earlier validated tool developed by Goel on Indian students. Mean, SD, ‘t’ test and analysis of variance were used to analyze the collected data.

Major findings of the study were:

1. The group of students following the individual laboratory method achieved significantly better on the psychomotor skills than did the lecture-demonstration group. (2) Students who followed the lecture demonstration method achieved at a higher level related cognitive skills than did the group of students which followed the individual laboratory method.

Malik (1990) attempted to study the impact of an investigatory approach upon student teachers' cognitive appraisal and its implications for the Science Teachers' Training Programme.

Major objectives of the study were:

1. To undertake an experimental try-out of structured reading material on modular basis for developing an understanding of concepts of investigatory approach in student-teachers of science.

2. To evaluate the impact of four modes of presentation of modular structured reading material, live demonstration, simulated peer teaching, and implementation in actual setting on cognitive appraisal of the group.

3. To explore the applicability of investigatory approach and its training programme as a viable strategy for preparation of science teachers.
4. To evaluate the effect of the various modes of presentation of modular structured reading material, live demonstration, simulated peer teaching and implementation on student-teachers' classroom functioning as adjudged through a rating scale on observed performance on investigatory approach.

The sample of the study comprised 54 B.Ed. student-teachers who were given experimental treatment under four stages. After each stage, Candidates Appraisal Scale was administered to ascertain the extent of cognitive appraisal shown by the subjects. The tools used in the study were Modular Structured Reading Material, Live demonstration, Simulated Peer-teaching, investigatory approach singly or conjointly. Mean, standard deviation, 't' test and coefficient of correlation were used to analyse the collected data.

Major findings of the study were:

1. The reactions of science teachers about the Investigatory Approach strategies were favourable,
2. Learning of Investigatory Approach through viewing live demonstrations resulted in the improvement of the cognitive appraisal about the approach.
3. Learning of Investigatory Approach through peer-teaching showed significant improvement in the cognitive appraisal.

Prakash (1990) observed that a large proportion of science concepts of both basic and applied nature require students to operate at the formal operational level of intellectual development. But a large majority of students (at secondary, higher secondary and even at college level) do not use formal operational thinking when dealing with such concepts and problems. They exhibit large differences in their ability to grasp and understand science concepts. This mismatch between the level of pupils' thinking and the intellectual demand of the subject-matter is one of the major causes of learning difficulties in science. He made a study on the effectiveness of concrete materials to enhance learning physical sciences.
The concretized instructions of four formal level science concepts were tried out on class IX students in two different schools. The instructions to one section of Class IX in each school were subjected to experimental treatment. The two sections in each school (control and experimental) were made equivalent on the basis of a pre-test. The researcher prepared materials for concretized instruction for all the four formal level concepts. A test of multiple choice items was developed and administered to both the groups. The differences were qualitatively analysed.

The major findings were:

1. It was found that the performance of student’s learning by concretized instruction was better than those learning by traditional instruction.

2. The average increments in marks of the experimental group of students on concrete level items were 8.8% and that of formal level items, 8.4%. As the tests comprised of items based on different logical operations and of concrete and formal operational level, the responses of such tests may be used to diagnose the learning difficulties of students. Remedial help can also be provided to them accordingly.

The use of concrete materials such as charts, models, analogies, more lucid examples and other manipulative materials based on concrete thoughts and sequencing of instruction in a three-stage cycle were found to help the concrete level operators in understanding the formal level concepts more effectively. The three-stages of learning cycles were introduction, concept formation and concept application.

*Shishta, Rama* (1990) investigated the effectiveness of guided discovery learning vis-à-vis the conventional approach to the teaching of scientific concepts in life sciences.

The major objectives of the study were:

(i) To identify through the analysis of subject-manner, conceptual hierarchies of the concepts of leaf photosynthesis, food chain, purification of air, balance of nature and to identify behaviour
specifications of each objective for teaching each concept, (ii) to develop a programme which would help to encourage curiosity and spirit of inquiry amongst the students about the world in which they live, and (iii) to compare the scholastic performance of concept achievement of pupils who undergo a teaching programme based on guided approach of teaching scientific concepts in biology with pupils who undergo the conventional type of programme.

The sample consisted of class VII students belonging to the Delhi Public School, R.K. Puram, New Delhi. Advanced Progressive Matrices and Achievement Test were used to collect the data.

The major findings were:

(1) The performance of the experimental group was superior to that of the control group on the concept achievement test in photosynthesis. (2) The treatment of teaching concepts of photosynthesis with blended strategies and different modes of teaching had brought significant difference in the achievement of biological concepts.

Narain, Archana (1992) studied the achievement of chemistry and students’ attitude towards science stemming from lecture-demonstration and small-group laboratory teaching methods.

The major objectives were:

(i) To study the effect of two methods of teaching chemistry, namely largely group lecture-demonstration method and small-group laboratory method, on secondary school students of Lucknow City, (ii) to find out the difference between the two teaching-method groups on achievement in chemistry and attitude towards science, and (iii) to assess the relationship between students’ attitude towards science and their achievement in chemistry. The sample consisted of 79 girls and 91 boys who were randomly assigned to the two teaching-method groups. The tools used included Chemistry Achievement Test (Forms A and B) constructed by the researcher and Attitude Survey for Junior High School of Fisher. For the treatment
programme, six lesson plans in Chemistry were prepared. The investigator ta
d by the two teaching methods. The data consisted of pre-test scores and
Comparisons were made by using ‘t’ test, critical ratio and the Pearson
correlation.

The major findings were:

(1) Some learning was found to be better through demonstration and some through practical
work. Neither of the methods was so superior to the other in teaching all aspects of science as to
force us to use it to the exclusion of the other. (2) In lessons connected with Analytical
Chemistry, there had been an increase in knowledge through the lecture-demonstration method,
while there was increase in understanding and laboratory skills through the small-group
laboratory method. The lessons in Inorganic Chemistry showed that there had been an increase
in knowledge through lecture-demonstration. In lessons of Physical Chemistry, no definite trend
was visible but the overall observation suggested that the laboratory method had a more positive
effect. (3) There was no effect of sex on the achievement in Chemistry.

Parida and Goswami (2000) studied the impact of using analogies as tools in science
teaching. They have attempted to describe the various dimensions of analogy as it is used in the
teaching learning of science and analyze the analogies available in the NCERT science textbook
for Class IX. They also added another dimension to the analysis on the basis of activity value of
an analogy. They found that although a number of analogies are available in the textbook, many
of them do not satisfy the criteria of analysis used. There are a few cases where students are
likely to develop misconceptions since adequate analogue explanation (AE) and explicit
analogical limitations (AL) have not been provided by the authors. They also observed that the
manner in which many of the analogies are presented in the textbook was also not inspiring. It
was also noted that the textbook cited more analogies in physical science than in biological
science.
Kishore, Lalit (2000) observed that science teaching can be effective in the cognitive development of students only when project work is done seriously and science curriculum is made child-centered. He further stated that in such circumstances alone, students will acquire the abilities to sense problems, collect observations, make interpretations and arrive at conclusions which are basic to effective learning of science.

2.2 STUDIES DONE ABROAD

2.2.1 STUDIES MADE ON THE IMPACT OF VARIABLES IN TEACHING AND LEARNING SCIENCE

Harlan, Donna Lynne (1986) studied the role of intuition in the teaching learning process. The study examined how science education might be improved in the elementary and secondary schools in America. This dissertation examined one of the elements of learning, intuition, in the context of today’s educational dilemmas. The investigation examined the premise that intuition has been proven to be a valid source of knowledge acquisition in the fields of philosophy, psychology, art, physics, and mathematics. However, upon examining a sample of teaching methods there seemed to be little reference to or acknowledgement of intuitive learning or teaching.

Enzor, Sharon Lynn Ball (1991) explored the differences between experienced and inexperienced secondary school science teachers’ use of questioning strategies. In addition, it evaluated the interactive thoughts which guide the use of questioning as a teaching technique in the science classroom.

An observational analysis was done of six experienced and six inexperienced secondary school science teachers in Metropolitan Nashville-Davidson Country Public Schools in the 1989-1990 school years. Each of these 12 teachers was observed three times while teaching
lesson plans written by myself. Three trained observers collected data through observational narratives, data sheets, and audio taped recording of classroom interaction. Further data were collected from the audio taped recordings by means of the Training and Assessment System (TAS). Data were collected regarding the teachers' method of selecting the respondent, student responses to questions, question clarity, integration of questions into a sequence, and the cognitive level of the questioning sequence was determined through the use of Blooms' taxonomy (1956).

Significant findings from statistical tests of six hypotheses and one research question were as follow: (1) Experienced secondary school science teachers integrate previously-learned material into questioning sequences more effectively than inexperienced teachers. (2) Experienced secondary school science teachers utilize higher-level questioning sequences as compared to inexperienced teachers. (3) The interactive thoughts to inexperienced science teachers focus more on instructional objectives, lack of materials, and time constraints than experienced teachers. (4) While asking no more questions, experienced science teachers spend considerably more time questioning students and probing for understanding than do inexperienced teachers.

Leming S James (1998) observed the barriers to the development of critical thinking in science classrooms:

1. Teaching as knowledge transmission – teachers consistently transmit knowledge to students in ways that students to think
2. Superficial coverage of content – teacher tend to cover superficially a broad range of information and ideas with students. The emphasis on coverage leaves little time for activities focusing on the development of thoughtfulness.
3. Teachers low expectations of students – students are perceived as incapable of succeeding are unwilling to attempt higher order thinking tasks.
4. Large number of students in a class – this phenomenon makes the management of classroom environment characterized by free and open exchange of ideas a difficult one.

5. Lack of teacher planning time – it is easier to construct lessons that require rote memorization than it is to construct lessons that challenge student’s thinking. It is also easier to grade rote learning assignment than to evaluate students written expressions of thought.

6. A culture of teacher isolation – teacher isolation does not encourage the sharing of information on creative and innovative instructional practices.

Woodbury, Jacqueline Margaret (1995) made a study on science teaching methods and strategies of exemplary fifth-grade teachers: a comparison between science as preferred and non-preferred subject.

Six exemplary fifth grade teachers who were selected by two independent sources in a double blind nomination procedure were unobtrusively observed in their classrooms and interviewed by direct questioning. During the research process each teacher was observed three times in both a preferred and non-preferred subject with science designated as one of the subjects. During the observations the participants conducted their classes as they normally taught. Field notes and tape recordings were made of the classes for later analysis.

The analysis of the teachers' methods and strategies found that in the preferred subject of instruction the exemplary teachers taught (a) student centered lessons, (b) which make connections with the student's real lives, (c) used little paper, and (d) did not utilize the textbook. Additionally, during science instruction the science preferred teachers used more manipulative, had a noisier class, and used more unique literal and constructive language than the science non-preferred teachers. During the post-observation interview the exemplary teachers gave candid impressions of their own teaching, and advice for other teachers and education in general. The science preferred teachers indicated (a) having positive experiences with science as a child,
(b) not enjoying science teaching at the beginning of their careers; (c) wanting to know the why; and (d) feeling confident of their ability to teach science at the time of the interview. Each of the science preferred teachers related the positive effects that workshops or graduate courses in science education had on their instructional abilities. The science non-preferred teachers (a) did not relate either a positive or negative feeling toward science as a child and (b) expressed their feelings of inadequacy when teaching science.

2.2.2 STUDIES MADE ON THE IMPACT OF INNOVATIVE INSTRUCTIONAL STRATEGIES IN TEACHING SCIENCE

McCune, Dianne Locke (1989) studied the effect of integrating Bloom’s taxonomy and the scientific method on critical thinking achievement and attitudes toward science. The major objectives of the study were:

1. To investigate the importance of the acquisition of basic competencies for elementary school science programs.

2. To improve the attitudes achievement and critical thinking skills.

3. To measure changes in student attitudes, achievement, and critical thinking skills due to two different types of participation in science teaching methods.

A total of 145 sixth grade science students enrolled in four rural elementary schools participated in the study. Two alphabetically assigned classes, an experimental and control formatted the sample from each building. The same instructor taught the experimental and control groups over a six-week period. The same science content was provided for both groups. The integration of a Cognitive System with the Scientific Method (ICSSM) was used in the experimental group and the control group was instructed according to the material and methods specified in the teacher’s manual.
The researcher found that:

1. Critical thinking skills improved considerably with the instruction of the ICSSM model when compared with the instructional model for the control group.

2. No significant changes occurred in attitudes and content achievement between the experimental and control group.

*Jyoung, Hong-Kee* (1990) made a study on the use of integrated curriculum materials, hands-on investigations in cooperative group activities and computer-based alternatives in science and basic skills instruction: a prototype for further study and for integrated curriculum development.

Eight teachers and their one hundred forty-nine (N = 149) ninth-grade physical science students from five urban schools in Philadelphia, received different instructional treatments within a single lesson. The treatments emphasized group organized hands-on investigation (HOI), demonstrated computer-simulated instructions (CSI), or demonstrated microcomputer-based laboratory (MBL). Immediately after each treatment, the science content test items (SCTI) were administrated to the students to determine: (1) to what extent the students were able to reproduce the graph they had just plotted from their data, or was plotted for them on a computer screen; (2) whether students were able to describe the results of scientific experiments using complete English sentences; (2) or if students were able to perform a simple mathematical computation related to the math used during the treatment. A students’ opinion survey (SOS) was administered to students to determine their preference for the use of HOI< CSI, or MBL in learning science, and an ethnographic survey was used to determine teachers’ perceptions of teaching science and improving basic skills through the use of HOI, CSI, and MBL.

The major findings of the study were:

1. The learning results were not different when HOI, CSI, and MBL was utilized instruction related to science and basic skills learning.
2. Students preferred the hands-on approach; however students who had previous experience with computer-based instructions preferred the MBL approach. Teachers preferred the HOI approach and perceived CSI and MBL as supplementary methods.

Smith, Patty Templeton (1992) studied the effect of instructional methods on student attitude and achievement. The purpose of this study was to collect and analyze data concerning the relationship between methods of instruction and attitude and achievement of students. The specific purpose was to further investigate if there is a significant relationship between the method of instruction of seventh grade science teachers and student attitude toward the subject and their achievement level in science at the end of their seventh grade school year.

The students were from districts that volunteered to assist with a field test of an instrument called Integrated Activities for Science Assessment (IASA), developed by the Missouri Department of Elementary and Secondary Education and the Center for Educational Assessment at the University of Missouri-Columbia, which was designed to assess student acquisition of science process skills.

The results of this assessment and the surveys of student attitude toward science gained from participating students were used to determine if there was a significant difference among students who had been taught using a lecture-based method of instruction, a hands-on method, or a combination of the two methods. To determine these differences, Kruskal-Wallis one-way analysis of variance by ranks were used with the independent variable being the method of instruction and the dependent variables being attitude and achievement.

The major findings of the study were:

Mean scores from all districts were obtained on both attitude and achievement for students who received lecture-based, hands-on or a combination method of instruction in science. Attitude mean scores for the three instructional groups ranged from 38.167 for the lecture-based group, 47.000 for the combination method group, to 50.833 for the group that received hands-on
instruction. The achievement mean scores for the three instructional groups ranged from 11.816 for the lecture-based group, 15.088 for the combination method group, to 18.401 for the group that received hands-on instruction.

**Digisi, Lori Lyman** (1993) investigated how high school biology teachers report the use of textbooks in their instruction, and the factors and attitudes associated with their instructional practices.

To gather descriptive information about teachers’ instructional practices and attitudes, the investigator mailed a questionnaire to 215 biology teachers in four states of North Eastern United States. Eighty percent (n = 149) of the teachers responded. The investigator selected 16 teachers, who were broadly representative of the larger questionnaire sample, to participate in follow-up interviews. Teachers were interviewed with their instructional materials present to enhance recall. The investigator used quantitative and qualitative analyses to process the data, capitalizing on the strengths of both methodologies to examine teachers’ views with breadth and depth.

The results indicated that high school Biology teachers view both reading textbooks and inquiry-based activities as essential to learning Biology. However, teachers varied considerably in how they reported assigning reading for different academic level classes. In general, for students in higher-level classes, Biology teachers reported assigning independent reading in challenging textbooks and using discussions to enhance students’ conceptual understanding. For students in lower-level classes, Biology teachers reported assigning reading to reinforce their lessons and using reading activities to improve students’ study skills. Teachers had positive attitudes about teaching students how to learn from reading science textbooks, but they appeared unsure of how to incorporate reading comprehension instruction into their Biology instruction.
**Kemp, Patrick** (1993) made a study on the use of three teaching strategies and their effects on the Cognitive developments of secondary science students. The cognitive development of secondary science students was investigated in this fifteen week study. Four sections of junior high school students were used, all taught in a different format. The four formats used were traditional instruction, cooperative learning, the learning cycle, and cooperative learning in conjunction with the learning cycle.

All of the students were given the Shipley-Hartford intelligence test and a cognitive development test known as "An Inventory of Piaget's Developmental Tasks" before treatment. The test consists of eighteen subtests measuring different aspects of cognitive development. Each section of students was taught in one of the four formats for a total of fifteen weeks. After that period, the students were again given the cognitive development test.

The major conclusion was that none of the three experimental teaching methods was superior to the others in producing gains in the cognitive development of secondary students.

**Spencer, Sonia Melisa Ayodele** (1993) studied the use of indigenous technology as a basis for science and technology education in junior secondary schools. It was a case study made at Sierra Leone. This study investigated two issues: (a) the usefulness of indigenous technology as an approach for teaching science and technology to junior pupils of secondary schools in Sierra Leone. (b) The factors which influence its implementation. In order to carry out this investigation, the author developed a fifteen lesson module on energy, using the 'coal pot', a significant indigenous technology device as center-piece. The module was tried out in three schools in Sierra Leone, using a total of 224 pupils. Other members of the sample were experimental teachers (who taught the module) and non-experimental (who only evaluated it) and science educators. Using the triangulation method, data were collected by achievement tests, questionnaires, structured and unstructured observations and informal discussions.
It emerged from the findings that

1. Indigenous technology is a useful approach for teaching science to junior secondary school pupils, irrespective of the problems encountered. The post-achievement test results show that on the whole, the module had a positive effect on pupils' learning.

2. The study also shows that indigenous technology has the potential to generate pupils' interest and improve their attitudes towards science.

It was further recommended among other things that science education researchers, teacher trainers, curriculum developers and teachers collaborate to develop and document instructional materials based on indigenous technology.

*Cartana I Pons, Josep* (1994) made a study on teaching Physics: Proposal of a new methodology with audio-visual aids. The investigator observed that experimental sciences, specifically Physics, generate a low level of academic performance. The demotivation of students (and often teachers) coupled with the discouraging results it naturally produces provided the impetus for the creation of a teaching method based on the nature of Physics, the characteristics of the students and the use of audio-visual aids. This method allowed a greater rate of assimilation of physical concepts and study techniques and stimulates a positive attitude in pupils (in the 11-14 age group).

The research is based on a cross-section of all of the Primary Schools in the province of Girona.

The analysis of this research gave rise to the following conclusions:

(1) There is significant evidence in favor of the proposed teaching method (2) Using textbooks can produce negative repercussions which must be taken into consideration. (3) Experimental Sciences must be interdisciplinary.

The investigator also added that the student would actually participate hands-on in the scientific activities rather than experience them through audio-visual aids. However this would
only be possible if sufficient time was designated for the science program and if, in fact, there were no pressure from curriculum deadlines.

The purpose of the investigation made by *Sturdivant, Leon Harlie* (1994) was to examine, assess, and evaluate the appropriateness of hands-on activity-based science for summer school remediation at the middle school level as related to students' attitude toward science; achievement in science; goal orientation as well as teachers and students perceptions of cognitive engagement within the instructional environment.

The research sample comprised of 130 middle school students, all whom were identified as at-risk. The students were in 10 science classes taught by four science teachers. A survey, a questionnaire, and a series of student and teacher interviews were used to examine and evaluate results. A pretest/posttest design was used for the survey and the questionnaire to compare and contrast data. Interviews were facilitated to evaluate teachers and students perceptions of the hands-on science approach. The study lasted for the four-week summer school period. Staff development in-services were provided to teachers who participated in this study. The purposes of the teacher in-services were to provide materials, strategies, and training in the use of hands-on activity-based approach to teaching.

The data collected suggested that student attitude toward Science improved with a hands-on approach. Students were generally involved in science when the hands-on approach was used and they described hands-on science as 'fun'. Student achievement improved greatly, 96% of all students in the study passed science. Results showed a goal orientation shift of 25.5% toward task-mastery. Students and teachers were significantly more cognitively engaged within the instructional environment. These results suggested that hands-on activity-based science was an appropriate and effective approach of summer school science remediation for middle school students.
Wade, Wilma Jean (1994) made a study on the effect of the traditional instruction, laboratory experiences and computer assisted instructions on ninth grade Biology students' science process skills achievement.

The purpose of this study was to determine the effects of traditional teaching methods, laboratory experiences, and computer-assisted instruction integrated with appropriate laboratory experiences on the development of science process skills among ninth grade biology students.

The sample consisted of 116 ninth grade Biology students attending schools in one city school district and one country school district and one county school district. During the first nine weeks of school, these students were taught biological topics designed for this study using traditional teaching methods (Group 1), laboratory experiences (Group 2) and computer-assisted instruction integrated with laboratory experiences (Group 3). After nine weeks of instruction, data were collected using the Test of Integrated Process Skills and the test of Science Related Attitudes.

The major findings of the study were:

Students in group 3 were more positive in their attitudes toward learning science when compared to the attitudes of students in Group 1 Group 2.

Data indicated that ninth grade Biology students can develop the 'process skills' if they are taught using traditional teaching.

Wilson, Julie Luft (1994) studied the effects of a demonstration class room on elementary teachers involved in a problems solving in-service programme.

The study described herein specifically looked at the effects of a Problem Solving Demonstration Classroom held in conjunction with an in-service. Thirteen elementary teachers participated in this year long study that examined their attitudes and beliefs, level of implementation, and perceptions of the Problem Solving Demonstration Classroom. These
teachers were elementary, had no science specialization, primarily female, were active professionally, and ranged in years of actual teaching experience.

Teachers completed attitudes and belief measures four times during the year. There was no significant difference on the belief measure. The attitude measure was significantly different for the component ‘Ease’ and ‘Comfort’ with Science teaching. In-depth interviews were conducted after participants attended the demonstration classroom. Teachers felt that that problem solving demonstration classroom allowed them to address their personal needs and there were multiple opportunities for professional dialogue.

Monaghan, Cheryl Ann (1995) made a study on science teaching methods in relation to student knowledge and aptitude. The purpose of this study was to determine if test scores and student attitudes would improve with the use of increased laboratory time and active science experiences compared to traditional teaching styles and limited hands-on experiences. This study also sought to measure how teaching methods affected the students’ interest and attitude toward science class.

Ninth graders from the same school campus were used in this experiment. Both groups were heterogeneous with respect to I.Q., sex, and rank in class. The control group was taught primarily by traditional teaching methods while the experimental group was exposed primarily to inquiry-based teaching methods.

The results of this study lead to the conclusion that science instruction that is activity-centered with students working in cooperative groups enhances student acquisition of knowledge and improves the student’s attitude toward science. Student acquisition of knowledge occurred with less emphasis on memorization because activity-centered, inquiry-based instruction provides multiple stimuli for learning. Activity-centered instruction improved student attitude toward and interest in science.
Kao, Wen Ming (1995) studied the effects of students’ participation in hands-on/minds-on activity on process skill achievement in sixth grade science class in Taiwan, Republic of China.

The purpose of this study was to determine the relationships between teacher behavior, classroom learning environment, student engagement, and student science process skill achievement.

The subjects, chosen from elementary schools in Taichung Taiwan, included 12 sixth-grade science teachers and their entire class for a total of 512 students. Of these 512 students, 48 were randomly selected as target students for observation. The behavioural data was pooled over a five-week period during science ‘hands-on/minds-on’ teaching-learning activities. Data were collected using three types of instrumentation to examine the relationships between teacher behaviour, student engagement, classroom learning environment, and science process skill achievement.

The major findings of the study were:

1. When teacher behavior was to illustrate a point, such as using audio/visual material, students were engaged in the learning tasks for the most part. When teachers were engaged in ‘active observation’ behavior, students were less likely to be engaged in the learning tasks.

2. Classroom learning environment had little impact student engagement.

3. None of the variables of teacher behavior, student engagement, or classroom learning environment appeared to have a significant impact on process skill achievement.

4. Teacher behavior variables did not appear to have a significant impact on classroom learning environment.

Because of the schedule required by the curriculum and the amount of information to be dispersed, little class time was spent on ‘hands-on/minds-on’ Science activities. Teaching
behaviour and classroom learning environment during ‘hands-on/minds-on’ lesson were not consistent with what is described in current research literature. Therefore, students in this study spent little time in learning activities where process skills were utilized. This may account in part for the lower than expected process skill achievement scores by elementary students in Taiwan.

Foley, Kathleen Emma (1995) studied the effect of co-operative learning and visual organizers in solving mole problems in chemistry. The study observed that the then chemistry students possess inadequate problem was the mole problem. The mole problem is a type of problem which requires many steps and multiple problem solving skills. It is a complex problem that confounds students. A variety of props to support problem solving were examined. These included visual organizers and cooperative learning; Visual organizers were expected to support working memory whereas cooperative learning techniques were expected to support the development of conceptual knowledge.

Students were assigned to one of four groups:

1. Visual organizer and cooperative learning;
2. Cooperative learning only;
3. Visual organizer only and
4. Teacher-directed or control.

Student’s problem solving ability on three units involving mole problems was assessed. The researcher found that:

1. The students in the combination group of visual organizers and cooperative learning outperformed their counterparts.
2. Females in the visual treatment outperformed females in the other treatment groups.
3. The combination of a visual organizer and a cooperative learning situation increased the ability of students to problem solve mole problems.
Calvert, Renna Marcia Biggers (1996) investigated the use of an innovative instructional organizer for teaching science.

This study was designed (1) to study the implementation of a 'How Can You Know?' (HCYK) instructional approach in school science and (2) to study how emphasizing this type of organizing strategy may expand students' understanding of science and influence attitudes in an increasingly scientific and technological society. A particularly valuable attribute of the HCYK organizer is its impact upon science as a way of thinking, a theme of scientific literacy.

This study is a presentation of observations, and accompanying conversations, interviews, and other information pertaining to the use of a HCYK teaching strategy by teachers. Observation of the teachers' instructional practices which emphasize nature of science, specially 'How Can You Know?', and their use of this strategy were objectives of this study. Other objectives included descriptions of the strategy's impact on students.

Class rooms of eight teachers provided the setting. The eight teachers, four form each of two school systems were observed for eight months.

A wide variety of data source were sued as sources of evidence study including participant observation, teacher and student interviews, teacher and student questionnaires, documents of classroom activities, and quantitative description derived from surveys and questionnaires.

The conclusions of this study point to an innovative instructional organizing strategy which when implemented as a frequently used instructional method improves students' understanding of science and their attitudes towards science. When teachers were observed using the HCYK method, there was an increase in time spent in classroom activities that seemed to translate into better understanding by the students. Impact on instructional strategies include more time spent in student-centered activities versus teacher-centered activities, more lab or research activities, better questioning techniques which encourage students to think, and more
consideration of evidence for answers to questions by both teachers and students. Students were found to enjoy science more when they were not dependent on the textbook but were given opportunities to solve problems for themselves using the HCYK strategy. Further, students were found to have developed pride and confidence in their own work when they completed tasks which required a high level of cognition. Based upon all evidence the use of a HCYK strategy proved to be a feasible strategy for use in teaching science, and teachers reported a positive impact on both their instruction and on their students from its use.

*Pedell, Brian Jeffrey* (1996) made a study on the approaches to visual discourse analysis of instructional material. The investigator felt that in a rapidly increasing demand for multimedia information delivery systems, technical communicators are focusing more attention on such research issues as how text/illustration interaction in instructional material facilities knowledge acquisition and comprehension. Through the formulation of detailed taxonomies and the performance of some innovative empirical studies, psychologists have shown that three types of information are essential to the comprehension and accurate performance of operation and assembly task instructions: Spatial, operational, and contextual information. Data from these studies also strongly suggest that instructional presentations with text and illustrations convey task-essential information more effectively than text-only or illustrations-only presentations.

In this dissertation and object-based framework is proposed for analyzing illustrations in operation and assembly procedures. This framework has been designed to fulfill two analytical objectives: to determine how well object depictions convey information necessary to perform step actions and understand task goals; and to assess the extent to which individual illustrations and entire pictorial presentations satisfy the discursive goals of clarity, coherence, and completeness.
In-service is a critical component in a teacher's professional development. Effective in-service allows for insight into alternative methods of instruction and changes in teaching behaviors, attitudes, and beliefs.

Pittman, Kim Marie (1997) made a study on use of analogies in science class rooms. The purpose of this research was to illuminate the phenomenon of analogy use in science class rooms by exploring the process and influence of analogies. The researcher conducted a combined quantity and qualitative study on the use and the effectiveness of teacher generated analogies, student generated analogies, and traditional instruction. Observations, interviews and test scores provided the data. The researcher found that instruction with analogies was more effective than tradition methods of instruction of protein synthesis to eighth grade students. An analogy was successful under certain conditions. These conditions included the amount of prior knowledge, the type of analogy used, and the goal of the analogy. Students with more prior knowledge in science performed better with the analogies than did the students with less background knowledge. Students with more science knowledge created and utilized analogies differently than students with less science knowledge.

Michalko, Michael (1998) distinguished productive and reproductive thinking in learning. He felt that generally students think reproductively – that is, based on relating similar problems encountered in the past. When confronted with problems we fixate something in our past that has worked before. Then we analytically select the most promising approach based past experiences, excluding all other approaches, and work within a clearly defined direction towards the solution of the problem. In contrast, in productive thinking when confronted with the problem one tends to come up with many different responses, some of which are unconventional and possibly unique. With productive thinking, one generates as many alternative approaches as one can. This form of thinking will lead to better understanding in science.
Labbo, D Linda (1999) stated that textbooks are widely viewed as the mainstay of content area instruction in many elementary schools. However, research suggests that textbooks, often written at a readability level that is too difficult for most students present a narrow view of concepts and essentially do not motivate to want to learn the content area information. Furthermore, researchers suggest that many children do not have the conceptual background knowledge vocabulary and an understanding of expository text structure that a necessary to comprehend informational text.

Stunkel, R Kenneth (1999) observed that learning at its best is an interactive group phenomenon. Students can gain experience working with one another by discussing critical questions after the teacher has laid a foundation for the discussions. A good lecture usually provides opportunities for students’ comments, questions and sustained knowledge exchange. Discipline for the students consists in listening, remembering, tracking arguments, exercising judgment, note taking and thinking about what is said in the light of assigned reading.

Weld, Jeffrey (1999) stated that all children enter school with roughly the same attitudes and abilities in science, but by high school females do not like science as much as males. He also observed that there is direct correlation between attitude towards science and science achievements. Female High School students take few advanced science test scores and a less interested in science related careers than their male classmates does. The science/technology/society approach is an innovative method, which proved to improve the student’s attitude towards studying science. In STS, approach students identify issues and share in the planning of activities that seek to find out the possibility of resolving the issues. The subject is on relevant and the shift is in the willingness to empower students. The classes normally started with brainstorming sessions in which individuals share topics of an ecological
nature that interests them. The teacher also facilitates discussions that guides students to sources, offers suggestion for experiments and assists with technology need.

2.3 A CRITICAL REVIEW OF THE STUDIES CITED

Science education, if properly conceived should primarily be concerned with the education of the mind rather than acquisition of isolated pieces of scientific knowledge. In the area of science teaching in India, there are basically two types of studies:

Status studies – which pertains to the survey of the present state of teaching of science subjects at different levels.

Experimental verification of the effectiveness of different methods or strategies of teaching.

The status studies revealed the present status of science teaching in India. Krishnan (1981) found the curricula of Kerala and Tamilnadu as weak in the dimensions of “methodical – instructional”. He found the curricula of Tamilnadu as additionally weak in basic laboratory work, self-study and practical work. Sundararajan (1988) observed that the hierarchy of objective related to the teacher gave more importance to knowledge, followed by understanding, application and skills. Rao and Gupta (1990) observed the status of urban schools as better than rural schools in providing facilities. It was also found that the schools taught science without practicals or laboratories; teachers taught subjects other than the one they are qualified for, weak expression of teachers and strictly confining themselves to the syllabus were some of the problems exposed through these studies.

Ashraf, Mohammed (1988) observed the other factors which stand as hurdles in providing science experiments in the class. Introduction of innovative approaches to teach science has to get through many hurdles for its implementation as shortage of space, time taken to implement innovation, lack of equipment, lack of properly trained staff and lack of parental cooperation.
When it comes to analyzing the difficulties in learning science, it was observed that students develop wrong concepts in the subject of science (Gadkari, 1982). Gadkari further identified the wrong concepts and developed a remedial teaching programme and evaluated the programme. Singhal (1983) observed that students did not read beyond the syllabus. Short duration courses, cyclo-styled materials given by teachers, special classes and inter disciplinary tasks were found to be useful in teaching science.

In the studies related to the impact of variable in teaching and learning science, Nathan (1983) observed that the medium of instruction had influence on learning science, Darchingpui (1989) observed significant differences in learning science with regard to sex of teachers, locality and science and non-science teachers handling science. Joshi (1989) observed socio-economic status to have a positive correlation. In addition to this teaching experience and teacher attitude has significant bearing on the performance of students.

When it comes to the second part of research in science – the effectiveness of the methodologies, the researchers have used a wide range of approaches ranging from observational approach, the practical method, the problem solving method, the project method, the environmental approach, science kits and combination of methods. But to answer the question, which one is effective, there is no clear cut answer. The methods were compared to the traditional approach and invariably the new method used by the investigator was claimed to be the best.

Vardhini (1983) validated multimedia strategy. Dighal (1985) attempted to scientifically improve the present methods. Agnihotri (1987), out of the selected methods of instruction, found systematic method of teaching physics to be more effective. Lambhate (1987) developed instructional materials and proved that it improved the performance of teachers. He further suggested that the materials did not equip teachers to think critically.
Mohapatra (1989) found that children made a great deal of conceptualization on the basis of their observations of day-to-day happenings. Raman (1989) found laboratory work and group discussion, Goel and Agbebi (1990) found laboratory method and Narain (1992) found demonstration and practical work as effective in teaching science.

The analysis of science education researches clearly indicates the need for identification of certain priority areas which can contribute significantly to the present day society. Efforts must be directed to the generation of knowledge concerned with how people learn science and how to instruct them. We need to know what helps whom under what conditions and which design or strategy leads to the most effective instruction.

Studies done abroad on the variables that affect the teaching and learning of science also revealed that there was little reference to intuitive learning. Harlan (1989) and Enzor (1991) observed that experienced school teachers integrate previously learned material into questioning sequences more effectively than inexperienced teachers. If science is chosen as a preferred subject of instruction, the exemplary teachers taught student centered lessons, made connections to real lives, had positive experiences with science and felt confident to teach science.

Studies done abroad on innovative instructional strategies revealed that, though different instructional strategies were used to teach science those which provided hands-on approach (Jyoung, 1990), integrated activities (Smith, 1992), indigenous technology (Spencer, 1993) and audio-visual aids (Cartana, 1990), where students actively participated in learning, proved to be highly effective.

Monaghan (1995) observed that activity centered instruction improved student attitude towards and interest in science. Foley (1995) observed that visual organizers supported working of memory and cooperative learning techniques supported the development of conceptual knowledge in learning science. Calvery (1996) pointed out that the innovative strategy, "How
can you know?” when implemented frequently went to the extent of improving students’ general understanding of science and their attitudes towards science.

Pedell (1996) observed that in addition to implementing an innovative instructional strategy, if teachers are oriented in the use of strategy it also effectively changes in a positive way, the teacher’s attitude, belief and behaviour on teaching science.

The review of science education researches clearly indicates the need for identification of certain priority areas which can contribute significantly to the present day society. The efforts much be directed with the generation of knowledge concerned with how students learn science, the status of science education in the present day society, the problems faced by the teachers and the learners in comprehending the science concepts, knowledge on the availability of resources and the most important of all is to make science reachable to all the students.

Review of status studies in science revealed the following factors:

1. The status studies pertained to the general status of teaching science in the form of infrastructure facilities.
2. Very few studies made an analysis of the status of textbooks.
3. An in-depth study on the concepts given in the science textbook, the nature of difficulties faced by the students in comprehending the concept, availability of resources for precise learning of the concepts and the impact of variables on the opinion of teachers and students on the nature of difficulty of the concepts was not mentioned.
4. Studies on difficulty analysis of science concepts pertaining to Tamilnadu State was also not mentioned.

Review on experimental studies on the effectiveness of various instructional strategies revealed the following:

1. Most of the studies pertained to identify the effectiveness of an innovative instructional strategy developed by the investigator. Irrespective of the nature of need of the concept,
the innovative strategy was applied and its effectiveness was evaluated. While implementing the innovative strategy, the nature of difficulty of the concept and the type of instructional strategy to be applied to help students overcome the difficulty was rarely taken into consideration.

2. Implementing instructional strategies based on the need of the concept and on the availability of resources and evaluating the nurturing effects of the strategy implemented was rarely studied.

Competence in teaching stems from the capacity to reach out to differing children and to create a rich and multi-dimensional environment for them to make science learning more meaningful. This demands that we widen our experience with different instructional strategies for different classroom setting to suit the other background variables such as nature of concept and availability of resources. The most important of all is that, when a strategy is introduced the teachers should also be oriented in the use of the new strategy. The teachers must be helped to model their behaviour to use this diverse range of alternative patterns of instruction. Each instructional strategy introduced should be validated to see that each student becomes a productive and effective learner.

With this wholesome view of contributing in a fruitful way to science education, the investigator attempted this innovative study under the heading, "IDENTIFICATION OF THE DIFFICULTIES IN LEARNING SCIENCE BY IX STANDARD STUDENTS AND PROVIDING REMEDIAL MEASURES". Hence the nature and extent of difficulties in learning science were identified, analysed and remedial teaching learning material were developed and validated in the experimental study and the same is presented in the next chapter.