Chapter-II

Review of Related Literature
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REVIEW OF RELATED LITERATURE

After defining problem and selecting variables in the study, every researcher needs background knowledge about research problem. Only knowledge of theoretical assumptions and definitions about research problem is not enough for commencement of research procedure. A huge amount of description is required for every study of research. Information about research design, sampling techniques, data collection procedure which have been used by other researchers in past, has importance for researcher. So review of studies which are pertaining to research problem is must for researcher.

Review helps investigator in planning of research. Investigator can know about various research techniques by reviewing research studies. A large part of review of literature actually is required to be done even before the commencement of research study. This is mandatory to make sure that your work is not a replication of a study that someone has already done earlier. A review of related literature is the procedure of collecting, selecting and reading books, journals, reports, abstracts and other references materials. A literature review is a systematic explicit and reproductive method for recognising, evaluating, interpreting and explaining the existing body of recorded work produced by researchers, scholars and practitioners. According to Best J.W (1986) “A brief summary of previous research and writing of recognized experts provides evidences that the researcher is familiar with what is already known and with what is still unknown and untested”. The related literature shows the way to the sources of significant and related ideas, theories & hypothesis and valuable information regarding problems & evaluation of usability and feasibility of current practices and empirical researches.

In present study, review of related literature is divided in four sections-
2.1 International studies related to Inquiry Training Model
2.2 Indian studies related to Inquiry Training Model
2.3 International studies related to science teaching
2.4 Indian studies related to science teaching
2.5 Critical appraisal
2.1 INTERNATIONAL STUDIES RELATED TO INQUIRY TRAINING MODEL

Collins (1969) has studied the importance of a strong Confrontation in an Inquiry model of Teaching. In this study, sixteen out of thirty students were randomly distributed into two groups. Each group participated in four sessions, lasting 45 minutes each. Each session was introduced with a problem that was logically incorrect (logic problem). The students would analyze the problem from different points of view. Both of the groups came to a conclusion on how to attack the logic problem using correct laws of implication and set theory. The experimental group was able to do this in 20% less time than the control group. At the end of the four sessions, a test consisting of eight logic problems was given to both groups. A test showed that the experimental group did significantly better. The confrontation for experimental group generated cognitive dissonance in each student that had to be resolved.

Bills (1970) studied to evaluate an attempt to increase the divergent thinking of eighth grade students with an inquiry. In this treatment, students were shown a demonstration consisting of a discrepant event. Students then suggested hypotheses and checked their hypotheses by asking questions, as in Suchman's method. Instructors answered these questions but did not identify the correct explanation. Six teachers each taught one experimental class and one control class, for a total of 306 students. Six creativity tests were given before and after the treatment, and the treatment effects were analyzed by analysis of covariance, blocking on sex and intelligence level. Two interactions were significant, but no significant main effect was found. It was concluded that, although students appeared to enjoy the inquiry sessions and were motivated to seek solutions from outside sources when discussions were left open-minded, the experimental treatment did not increase their creative production.

Jones (1972) reported a study demonstrating the effects of acknowledgment of success as related to self-concept, problem solving behavior, or science concept development of seventh-grade students. Forty nine students were randomly assigned to either the experimental group (those who received acknowledgment of successful autonomous discovery) or the control group. Both groups were taught by the investigator utilizing Suchman's Inquiry Development Program materials and
techniques. Pretest and posttests included the self-concept as a Learner Scale-Secondary, the Cooperative General Science Test, and the TAB Science Test. The t-test for independent samples was used to determine significance of mean difference scores. A correlated t-test was used to determine the significance of change between mean pretest and posttest scores on each instrument used. Analysis of the data revealed no significant difference in the changes in self-concept, problem solving behaviour, or science concept development between those students whose success was acknowledged and those whose was not. It was concluded that the acknowledgment or lack of acknowledgment of successful autonomous discovery by these students did not affect their self-concept as a learner in relation, problem solving, or class membership.

Garbally (1974) studied the effectiveness of science inquiry lessons on the development of the skill of classification in inner city kindergarten children. The study attempted to answer the questions - (i) Do the science inquiry lessons affect the classification behaviour of the children? (ii) Will the children involved in the science inquiry lessons retain any increased ability to classify three months after the termination of the lessons? The study concluded that the science inquiry lessons will produce no significance change in classification, and development and it can be altered by lessons which emphasize concrete experience with objects. The increased ability to classify the children who participated in a follow up study which occurred three months after the lessons were terminated.

Amore (1976) has set out instructional procedures using Inquiry Training Model with teacher candidates. He derived the rationale for the study from three recent developments in teacher education: competence based teacher education, Models of Teaching by Joyce and Weil, and instructional systems facilitating demonstration of teacher competencies. It was hypothesized that student teachers participating in an instructional system which included symbolic and perceptual modeling and microteaching experience would attain higher performance scores than subjects exposed to instructional procedures using symbolic and perceptual modeling or symbolic modeling alone. Twenty-four subjects formed three groups, eight subjects per group. One group participated in an instructional procedure using symbolic modeling of the Joyce-Weil inquiry training model of teaching. The second group participated in symbolic and perceptual modeling of the model, and the third group
observed both types of modeling and participated in microteaching sessions to practice the model. Each subject submitted audio tapes with plans of six science lessons taught: three pre-instructional and three post-instructional (inquiry training model) lessons. Frequently in real classroom situations than would student teachers who received only general instruction in the inquiry strategy. Sixteen subjects formed two groups. One group received general instruction in the inquiry strategy of teaching and the second group, in addition, participated in an instruction procedure which included symbolic and perceptual modeling of the Joyce-Weil inquiry training model and microteaching experience in practicing the model. Subjects submitted audio tapes with plans of six science lessons taught during the last three weeks of their student teaching experience in situations in which they were given the responsibility for the decision-making involved in the lesson planning. No restrictions were made on the teaching strategies to be used by the subjects. All subjects in this study were seniors majoring in education in a liberal arts college and student teaching in elementary schools in New York city. A statistical analysis of the data (tapes and plans) rejected the hypotheses. Subjects participating in perceptual modeling and microteaching instruction were able to implement such moves as presenting children with discrepant events, focusing and summarizing. Instructional procedures, however, were ineffective in teaching subjects such key elements of the models as pupil inquiry, pupil evaluation and pupil reflection on the inquiry process. A study of the findings revealed that several factors appear to have interfered with or influenced the subjects' implementation of the inquiry model of teaching. Subjects reported that their cooperating teachers were unfamiliar with this model of teaching and the children with whom they worked consequently were not used to an inquiry style of learning. It was concluded that instructional procedures designed to teach pre-service teachers a teaching strategy should involve the cooperating teachers with whom the student teachers will be working. It was also recommended that more than one symbolic and perceptual demonstration of a model of teaching and more than one microteaching session per subject be programmed to teach pre-service teachers to implement a strategy. Given the distinctive teacher and learner roles of the model selected for this study, it was further suggested that children, instead of subjects' peers, should be present as pupils in the microteaching session for more meaningful training sessions. The last consideration which evolved from the study was related to the concepts of strategies, flexibility and appropriateness. Subjects were evaluated on ability to
implement the model in unadulterated fashion. It was recommended that for more meaningful teacher education, strategies should not be conceptualized nor evaluated apart from the concepts of flexibility and adaptation to the pupils' involved and the evolving learning situation.

Elefant (1980) Studied to determine the inquiry strategies which would be acquired by deaf children involved in a science-oriented inquiry development program based on Suchman's (1966) discrepant event approach. 27 Deaf students, aged 10-13, in five groups (one of 7 students, one of 5, and three groups of 4) responded to eight discrepant events related to the science topic of heat. Intensive data on the inquiry strategies used by the students were obtained from direct observation and analysis of video-tapes for 10 students. The acquisition of inquiry strategies by the deaf students was comparable to those of the hearing senior high school students for whom Suchman had devised the inquiry development programme. All of the deaf students in this study were able to acquire inquiry strategies.

Hansler (1985) studied the effectiveness of the Cognition Enhancement Technique for teaching a selected group of cognitive skills. A research project conducted during the 1984-85 school year. "Inquiry Training," a teaching technique promoted during the 1960s, involves students gathering information about a discrepant event or puzzling situation, and formulating theories to explain the event. Continuing the work of two studies into the efficacy of Inquiry Training (subsequently renamed Cognition Enhancement), a more refined third study was conducted to determine whether forms 2 and 3 of the Test of Cognition Enhancement Skills are equivalent; whether students' test scores would reach a plateau within 16 cognition enhancement instructional sessions, and whether students receiving cognition enhancement instruction would score significantly higher on the Test of Cognition Enhancement Skills than would control students receiving no such instruction. Students in grade 5 completed forms 2 and 3 of the Test of Cognition Enhancement Skills, each item of which measures one of 18 cognition enhancement skills. The result indicated the following: (1) students with higher basic ability scored better on both the pretest and the posttest that did students with lower basic ability, (2) forms 2 and 3 of the test were shown to be equivalent (3) multiple exposure to a specific form of the test resulted in slightly elevated test scores, (4) students who participated in 16 cognition enhancement session scored significantly higher than did control students, and (5) student growth in
the cognition enhancement program did not reach a plateau during the 16 sessions. (Study data, subsets of cognition enhancement skills, schedules for cognition enhancement instruction, and forms 2 and 3 of the Test of Cognition Enhancement are appended).

**Donald (1987)** studied effect of inquiry and expository models of instruction in large biology classes of the junior high school in Taiwan. Three sets of blocking factors were used to observe and study the effects on the students of different levels of cognitive development, ability, and involvement in class activities. The pretest-midtest-posttest design was applied to measure students’ achievement on knowledge gains, reasoning' and application and problem-solving skills. The ANOVA was the primary statistical procedure. Scheffe's method was applied for posthoc comparisons. Post-hoc analysis indicated that active students apparently achieved better than the inactive students on all dependent variables measured. The greater number of active students produced in the classes of the inquiry learning model suggested that substantial involvement is probably an essence to effective learning in biology classes. In the final part of the study, the experimental classes were compared with control classes (N=320) in the same school district. Analysis of covariance (Covariate equal the score on the Group Embedded Figures Test) and Tukey's Test indicated that the experimental groups dominated significantly (p<.01) over the control group on all dependent experimental groups on the achievement of knowledge gain and inductive thinking, but the students in the inquiry model achieved significantly (p<.01) better than those involved in the expository model on divergent thinking skills.

**Scruggs, Mastropieri, Bakken and Brigham (1993)** found that an inquiry based teaching approach was more effective for teaching science to students with learning disabilities than a textbook based teaching approach. Twenty-six junior high school students were taught one unit of science syllabus using an inquiry approach and one unit using a textbook approach. The results showed that on both immediate achievement test and one-week delayed recall tests, students scored higher when they were taught with inquiry based teaching approach. Also, student satisfaction data showed that over 95% of the students preferred the inquiry-based instructional condition.
Scruggs and Mastropieri (1995) also studied how characteristics of students with mental retardation were related to their ability to perform in inquiry-oriented science settings. The researchers took interviews of students and teachers, assess students’ performance and observed the students in the classrooms. The interpretation of the results of data analysis revealed that the students did exhibit deficit in cognitive abilities (i.e., attention, semantic memory, and logical reasoning) as well as the psychosocial characteristic of outer concentration that appeared to directly affect participation in inquiry-oriented science. However, the researchers also found that with some special adaptations such as reducing vocabulary demands, using graphical illustrations, the use of multimedia presentations, carefully structured questions, and making students comfortable with science materials, mentally retarded students can participate in and benefit from inquiry-based science instruction.

Kanli (2003) studied the effects of a laboratory based 7E learning cycle model (a type of inquiry learning approach) and verification laboratory approach on the development of students science process skills and concept achievement using science process skills test and force concept inventory to compare skills and conceptual achievement of students in control and experimental groups. They found that the use of 7E learning cycle model of inquiry based laboratory approach applications is more effective than the verification laboratory approach applications in terms of students’ science process skills and conceptual achievements.

Salih (2004) investigated the effects of inquiry-based instruction on the development of integrated science process skills in primary school teacher trainees. The objective of the study was to determine whether inquiry based instruction is equally effective to develop integrated science process skills of primary school teacher trainees classified as being concrete, transitional, and formal questioners. Post-test scores were analyzed to compare the groups’ integrated science process skills after instruction. Analysis of data showed that the students in formal group performed significantly better than the students in both concrete and transitional groups with respect to the achievement of integrated science process skills. Formal students gave more positive responses to the instruction than concrete and transitional students. Consistent with findings in other studies, most of the primary school teacher trainees were found to be in concrete and transitional groups. These findings suggest that teachers who wish to use inquiry
based instruction to teach integrated science process skills should start employing an additional instructions to improve their students reasoning skills.

**Vanossdall, Klentschy, Hedges and Weisbaum (2007)** conducted a series of experimental and quasi experimental studies for testing the effect of scaffold guided inquiry instructional system on students’ achievement and compared the effect to those from other instructional systems. Sample consisted of 20 fifth grade teacher and 563 students from four schools who were randomly distributed in control and experimental group. They concluded that scaffold guided inquiry based instruction in combination with kit based curriculum is more effective on science achievement than text book instruction.

**Lambert and Ariza (2008)** in their report investigated the effect of an inquiry-based Earth systems curriculum and strategies for teaching on diverse students, which were included in the curriculum. The curriculum was implemented on fifth grade students having varied linguistic, cultural, and socioeconomic backgrounds in five schools in a large, southeastern U.S., urban school district. At the end of the curriculum, all schools showed statistically significant improvement in scores on two assessments: (1) an Earth systems unit test and (2) a sample of National Assessment of Educational Progress (NAEP) and Third International Mathematics and Science Study (TIMSS) items. Students’ perspectives about the cognitive and affective domains of the curriculum were discussed as implications of the findings and recommendations for future research.

**Khan et al (2011)** conducted a study to see the effect of inquiry-based instruction as a supplementing strategy on the academic achievement of secondary school students in the subject of chemistry. The major objectives of the study were to find out the relative effects of inquiry based instruction as supplementing strategy on the academic achievement in chemistry and to explore the difference between treatment effects on the students of high and low intelligence. The performance of high achievers of experimental group on post-test was significantly better than that of control group. In case of low achievers, the difference between the means on post-test was not significant. Hence, it can be concluded that the performance of the high achievers on the post-test was significantly better than that of low achievers. Since there was no significant difference between the mean scores of low achievers of experimental and
control groups, it effectuated the significant of treatment. The overall results of the study indicate that inquiry based instruction, as a backup strategy to support traditional teaching methods, improved students’ achievement in the subject of chemistry at secondary level with higher achievement gains for the groups of high achievers. The results of the study were mostly in line with those of previous researches carried out in other cultures. However, individual variations were found regarding the impact of inquiry.

Khan and Iqbal (2011) in their study named “Effect of inquiry lab teaching method on the development of scientific skills through the teaching of biology in Pakistan” found on the basis of analysis of data that there was a positive improvement in the perception of development of scientific skills after having experiences in inquiry lab teaching method. The significant conclusions regarding the scientific skills and its components like observing, manipulating, classifying, drawing, measuring and communicating showed that scientific skills could be developed in students at secondary level through inquiry teaching method as well as traditional teaching method but inquiry teaching method was more effective in developing skills. This study proves that inquiry teaching is a more effective method of teaching biology in developing scientific attitudes and skills as compared to traditional method of teaching. Inquiry method can be made more effective through integrating it with activity method. It is therefore, suggested that science teachers may apply inquiry lab teaching method to other subjects at secondary level.

Hughes et al. (2013) investigated effect of training in inquiry based learning pedagogy to teach biology on graduate teaching assistants in Portugal. Graduate teaching assistants were trained to instruct according to either inquiry based learning pedagogy or general teaching practices. Sample included 52 graduate teaching assistants. Teaching effectiveness of graduate teaching assistants was evaluated through: (1) a nine-factor student evaluation of educational quality; (2) a six-factor questionnaire for student learning; and (3) course grades. Ratings from both graduate teaching assistants and undergraduate students indicated that the inquiry-based learning pedagogy training has a positive effect on teaching effectiveness.

Abdi (2014) studied the effects of inquiry-based learning method on students’ academic achievement in sciences lesson. A total of 40 fifth grade students from two
different classes were selected for the study. Students were selected through purposive sampling method. Experimental group was taught through inquiry-based learning method whereas the other group (control group) was taught through traditional method. Duration of treatment for this experimental study was eight weeks. To find the effectiveness of inquiry-based learning method over traditional instruction, a science achievement test consisting of 30 items was administered as pre-test and post-test to students both in the experimental and control groups. For the statistical analysis, Analysis of Covariance (ANCOVA) was used in this study. The results revealed that students who were taught through inquiry-based learning achieved higher score than the ones which were instructed through the traditional method.

**Harahap et al. (2016)** examined effect of inquiry training model on science process skills of students. Quasi experimental design (non equivalent pre test post test control group design) was employed for this study. Experimental group was taught through inquiry training model and control group was taught through conventional method of teaching. Students in experimental groups achieved science process skills more significantly than students in control group.

**Turnip et al. (2016)** in this research study aimed to analyze the differences in problem-solving ability of Physics students taught through Inquiry Training model based on Just In Time Teaching and conventional learning taught by cooperative so that it can be seen whether there is influence learning model Inquiry Training based Just In Time. This research employed a quasi-experiment study. Population was comprised of students of program Physical Education Department of Physics, State University of Medan. Sample selection is done by cluster random sampling. The instrument used was a test of problem solving abilities. Data was analyzed using anova. Results showed that there are differences in problem solving capabilities of physics students through Inquiry Training model and cooperative learning model so that it can be concluded that there is positive influence of Inquiry Training model on problem solving abilities of physics students.

### 2.2 INDIAN STUDIES RELATED TO INQUIRY TRAINING MODEL

**Dubey (1985)** studied the effectiveness of ITM in learning outcomes. The sample consisting of 25 students was divided in two groups. Raven's standard progressive matrices, Passi test of creativity, Self made achievement test. Reaction scale of
Katiyal (1985) were used. Student achievement scores of VIII class was taken as their previous achievement scores. Students reacted favorably toward ITM. The relationship of fluency, flexibility, total verbal creativity and originality, total non-verbal creativity with intelligence were low and negligible respectively. ITM was superior to TM in teaching.

Katiyal (1985) compared the learning outcomes of the pupils by Inquiry Training approach and Traditional Teaching, and also compared the intelligence and scholastic achievement of the pupils. The sample was comprised of 10 students of VII standard constituting the experimental group and 10 students of VII standard constituting the control group. The measurement tools namely, Achievement test and reaction scales developed by investigator, Raven’s progressive matrices (coloured form) were used. (1) The achievement of the students of experimental group was significantly higher than achievement of students of control group. (2) Mean intelligence of experimental group was significantly higher than the mean intelligence of the control group. (3) The students of experimental group were significantly higher in their previous achievement and final achievement than the students of the control group. (4) The reaction of students of experimental group was highly in favour of new approach.

Passi, et al. (1985) investigated to find out effectiveness of training for teaching through concept attainment model (CAM) and Inquiry Training Model (ITM) in terms of understanding of and reaction towards the models. They also investigated the resultant willingness of the teacher educators to implement the models of teaching in teacher education programme to develop a strategy of training for teaching through models of teaching. The sample was comprised of 45 teacher educators drawn from 25 institutions of nine states and five union territories. An 8-days workshop on models of teaching was organized at DAVV, Indore. The single group pre-test post-test design was employed in the study. The treatment included orientation in the theory of model, a lesson plan guide and a teacher analysis guide through lectures and discussions. This was followed by demonstrations and practice. The tools used in study were: Theory check up for ITM and CAM developed by Bruce Joyce and Marsha Weil, Reactions scale for CAM and ITM and Willingness scale for implementation of models. The data was analyzed by computing Mean, S.D., Coefficient of correlation and by employing t-test and chi-square test.
The findings are: Training in both CAM and ITM brought significant favourable change in teacher educators’ reaction towards the models of teaching. The level of understanding of ITM and CAM did not have effect on teacher educators’ reaction towards the models of teaching. Training in CAM and ITM in the form of lecture, discussion, demonstration and peer practice plus feedback enhanced the understanding of theoretical aspects of the models of teaching by teacher educators. Teacher educators were agreed to implement models of teaching in the teacher education program if a support system was available; so training strategy comprising theoretical discussions, demonstrations and peer practice plus feedback was found effective in terms of developing, understanding favourable reactions and willingness to implement models of teaching in teacher training program.

Dadge and Wagh (1986) studied the effectiveness of training of the student-teachers in ITM in terms of understanding reaction towards the ITM model competences and willingness. Sample comprised 24 student-teachers who were divided in two experimental groups. Tools such as TC, MTC, RS₁, TAG, RS₁, WS₁, and WS₂ were used. The following conclusions were derived. The reaction scores of the student-teachers as trainee learners and practicing' teachers did not differ due to different treatments given to the groups. (2) Pupils expressed favourable reaction towards ITM. (3) Willingness of student-teachers to implement the model in school was favourable. (4) The two groups were found to be equal before orientation and differing after orientation in theory knowledge of ITM. (5) The two groups were found to be equal in performance during peer practice feedback stage (PPP). (6) Group was found superior to the group E₂ in terms of model competence at coaching stage. (7) By and large the resultant willingness of student teachers to implement model in school was favourable. 8) The reactions of pupils learning through ITM were found favourable.

Malhotra (1986) studied the effectiveness of ITM with variation in demonstration and peer-practice in terms of Specific Teaching Competencies of pre-service Teacher Trainers. Out of 60 volunteers, 24 student teachers were selected for this study. They were divided in two experimental groups. TC, MTC, TAG, RS₂, and RS₃ were used. Before orientation the two groups were found similar on TC but after orientation group E₃ performed better on MTC of ITM. At PPF and coaching stages the gain scores of group E₂ were more than E₁. The student-teachers of group E₁ reacted more
favourably as trainee learners and as practicing teachers. The school students had equally favourable reaction as taught by student-teachers belonging to \( E_1 \) and \( E_2 \) groups.

**Pandey, S.N. (1986)** investigated to compare the effectiveness of AOM and ITM for teaching social studies to class VIII students. The main objective of the study was to compare the effect of the AOM, ITM and Conventional Teaching (CT) in terms of pupils’ achievement and attitude towards Social Studies. The tools used were: Samanya Mansik Yogyatha Parikshan by M.C. Joshi; SES index by R.P. Verma and P.C. Saxena; Upabhdi Parikshan developed by the researcher; Samajik Adhyayan Ke Prati Chhatra Abhivradhhi Talika developed by the researcher and Shikshan Ke Prati Chhatra Pratikriya Suchi developed by the researcher. The sample was comprised of 86 class VIII students selected through purposive sampling technique. The experimental groups were labeled as AOM group (29 students), ITM group (28 students) and the control group (29 students). ANOVA, t-test and Chi-square test were used for analysis of data. The major findings are: studied teaching strategies had different effects on the pupils’ achievement. The difference in means of gain scores of achievement due to AOM and Conventional teaching was significant at the 0.05 level of significance, difference due to ITM and CT was significant at the 0.01 level of significance and difference in gain scores of achievement due to ITM and AOM was not significant. There was no significant difference between the AOM and ITM; AOM and CT; and ITM and CT in terms of students’ attitude towards social studies; and pupils reacted favourably towards the ITM and AOM.

**Sushma (1987)** studied the effectiveness of biological science inquiry model and concept attainment model in comparison of conventional method of teaching. Effectiveness of these three teaching strategies was compared through achievement in biological science. So 78 VIII grade students were selected for sample of this study through purposeful sampling and their achievement in biological science and attitude towards biological science were assessed. This sample was divided into 2 experimental and 1 control groups. First experimental group was taught through biological science inquiry model (BSIM). Second experimental group was taught through concept attainment model (CAM) and control group was taught through conventional method of teaching (CMT). These 3 groups were compared in terms of
achievement in biological science and attitude towards biological science. Tools used were

1. Samanya mansik yogyata parikshan by M.C.Joshi.
2. SES Index by R.P.Verma and P.C.Saxena.
4. Jiv vigyan ki prati chhatra abhivrraddhi mapan by researcher.

Major findings were-

1. CAM and BSIM were found effective in term of achievement. CMT was not found effective. t-test was used for finding effectiveness.
2. CAM was more effective than BSIM.
3. Students in CAM group had more favorable attitude towards biological science than students in BSIM group.

Pandey (1988) compared pupils’ attitude towards social studies taught through ITM and Conventional Teaching (CT). The sample comprised two groups-The ITM group and CT group consisting of 28 and 29 students having 57 class VIII male students in all respectively. The tools, namely Samanya mansik yogyata pariksha and Sama Abhivritti Talika were used. Pretest-posttest control group design were used. ITM was superior to CT in its effect on students' attitude towards social studies.

Baveja, Bharti (1989) compared the effectiveness of traditional method of teaching and model approach which was combination of concept attainment model (CAM) and Inquiry Training Model (ITM) ie. CAM+ITM. Effectiveness was evaluated in term of attaining biological concepts. Investigator selected 22 English medium IX class students for sample by using purposeful sampling technique. Sample was divided in 2 groups- 1. Experimental 2. Control. Both groups were taught topic- “morphology of flowering plants” for 12 hours. These 2 groups were taught by investigator. Control group was taught through traditional method of teaching while experimental group was taught through model approach (CAM+IMT). Experimental and control groups were matched on the basis of scores in pre test. Variables like age, gender and IQ were also assessed and considered in matching. Post test was taken on taught concept in both groups. A delayed post test was taken after 10 months. Pre, post and delayed post tests had objective type test items and diagrams and specimen for identification.
After the analysis, experimental group was found to have better concept attainment. It also had better retention enhancement. So model approach was more effective.

**Lima, C.G.D. and Sugandhi (1989)** studied the effect of Inquiry Training Model (ITM) of teaching on pupils’ creativity. 200 students of IX grade selected for sample. The tool used in the study were Torrence test of verbal creativity, Non verbal test of intelligence prepared by Dr.Nafde and OTIIS test of mental ability for secondary school students. A pre test and post test control group design was used and a Two way ANOVA was used for analysis. It was found that training in the inquiry model improved the creativity of the students significantly.

**Dutta S. N. (1990)** has reported "A study to determine effect of ITM video instructional material on teaching competency of teachers through ITM." The sample consisted of 20 student-teachers of D A W Indore admitted during 1989-90 academic session. Theory check up developed by Yadav, and reaction scale for ITM and TAG were used. Following conclusions were made.(1 ) The video instructional material was found effective in terms of theoretical understanding of ITM and reaction towards ITM. (2) Students developed good understanding of ITM and favotrtrakle reaction towards ITM. (3) The practice of ITM did not influence but demonstration did influence the teaching of students in the use of ITM.

**Singh (1990)** compared the effectiveness of Inquiry Training Model and concept attainment model over traditional model for the teaching of physical science. The finding revealed that Inquiry Training Model and concept attainment model are equally effective and both the model established their superiority over traditional models of teaching.

**Subudhi, Bhagvan (1991)** investigated comparative efficacy of different variations in the training strategy for teaching according to ITM of teaching in terms of performance on : Theory Checkup (TC) ; Teaching Assessment Guide (TAG); and Reaction Scale.

This study was also aimed to find the feasibility of integrating training for teaching according to ITM of teaching with the practice teaching programme and school teaching in terms of student-teachers’ and pupils’ reactions. The sample consisted of 24 student-teachers of Bachelor of Education course, which was divided into 2 groups
of 12 each, one experimental and another control group which were matched on
academic qualifications and method subjects selected by student teachers in sample.
Age, Sex and SES were also controlled. Control group pre test and post test design
was used to study the effectiveness of the training strategy in ITM of teaching. The
training program included orientation of theory of the model (TO), followed by
discussion and explanation of Lesson Plan Guide (LPG) and Teaching Analysis Guide
(TAG). After orientation, training to develop lesson plan was given with help of
LPGs followed by observation by using TAGs. Then student-teachers prepared their
lesson plans according to ITM of teaching. Lessons of 20 minutes were practiced and
reactions of students and student-teachers were recorded.

The following tools were used in the study.

1. Indore theory checkup for ITM to collect data on theoretical understandings of
   the model.
2. Reaction scale on ITM, to collect reactions of student-teachers towards ITM.
3. TAGs for analysis of teaching during practice
4. LPGs for planning of lessons.

The data was analyzed by using statistical techniques like measures of central
tendency, ANCOVA and t-test. The findings showed that in theory orientation, the
two groups of student –teachers were initially nearly equal in their pre test scores but
after training the group in which demonstration was immediately followed by
feedback, showed more gain on TAGs than the group in which, a long time interval
was existed between demonstration and feedback. The findings also reveal that
students showed their reaction towards student-teacher rather than the model of
teaching adopted by individual teacher. Secondly, students preferred only those
methods where there was no noise and disturbance in the class.

Gupta (1993) assessed differential effectiveness of concept attainment model,
inductive thinking model and Inquiry Training Model of teaching on mental process
and attitude towards science through science teaching at class IX stage. The
objectives of the study were (i) To study the effectiveness of teaching through concept
attainment model on (a) development of pupil’s mental process and (b) development
of favorable attitudes of the students’ towards science, (ii) To study individual
effectiveness of teaching through inductive thinking model on (a) development of
(i) To study individual effectiveness of teaching through Inquiry Training Model on (a) development of pupil’s mental process and (b) development of favorable attitudes of the students’ towards science, (iii) To study individual effectiveness of teaching through Inquiry Training Model on (a) development of pupil’s mental process and (b) development of favorable attitudes of the students’ towards science, (iv) to find out relative effectiveness of teaching through concept attainment model, inductive thinking model and Inquiry Training Model in developing mental processes of the students, (v) to find out relative effectiveness of teaching through concept attainment model, inductive thinking model and Inquiry Training Model on development of favorable attitude of the students towards science. The major findings were (i) concept attainment model and inductive thinking model has been found to be effective in developing reasoning and scientific creativity as well as favorable attitude towards science among the students, (ii) Inquiry Training Model has been found to be effective in developing reasoning and scientific creativity as well as favorable attitude towards science among the students, (iii) Inductive thinking model and Inquiry Training Model were found to be equally effective in developing problem awareness ability among the students.

Patnik, Sabita P., J.R.Ugru (1994) studied the effect of teaching through Inquiry Training Model on achievement in biology with respect to gender difference and different intellectual quotients. The sample consisted of 56 students of class VIII, divided into two groups of 28 students each, an experimental group and a control group. Participants were matched by pairing in terms of percentile score obtained in Raven’s progressive matrices test. In this investigation, the pre –test and post-test equivalent group design was used to assess the relative effectiveness of Inquiry Training Model and conventional methods of teaching on achievement in biology. The experimental group was exposed to treatment (teaching strategy of inquiry training mode) and control group was taught as usual (through conventional methods of teaching). The effect of Inquiry Training Model and conventional method of teaching on respective group was assessed with the help of pre testing, post testing and by calculating the gain scores (ratio of post test score and pre test score) in the achievement test and comparing both the groups. It was observed that there was a significant difference at all level of objectives i.e. knowledge, understanding, application and total scores of achievement in biology among experimental group and control group. This shows that the Inquiry Training Model was more effective in achieving all the objectives of achievements in biology. There was a significant
increase in achievement of students from pre test to post test, when they were taught through Inquiry Training Model, irrespective of sex and intellectual levels. Students achieved better in biology when they were taught by Inquiry Training Model of teaching.

Raina (1994) compared advance organizer model and biological science inquiry model in teaching of biology. The major findings were (i) advance organizer model is significantly effective in teaching of biology in terms of pupil’s achievement, (ii) biological science inquiry model is significantly effective in teaching of biology in terms of pupil’s achievement, (iii) advance organizer model is significantly more effective as compared to biological science inquiry model in terms of pupil’s scholastic achievement, (iv) biological science inquiry model is significantly more effective as compared to advance organizer model in terms of pupil’s interest in inquiry activities, (v) Biological science inquiry model is significantly more effective than advance organizer model in terms of pupil’s reaction towards models of teaching.

Alam (1996) conducted a study to comprise the relative effectiveness of inductive thinking model and Inquiry Training Model for teaching biology to the students of secondary schools. The major findings were (i) for concept learning and retention in biology, inductive thinking and inquiry model are more effective than the conventional teaching methods, (ii) inductive thinking model is more effective as compared to Inquiry Training Model in terms of students’ concept attainment in biology, (iii) mental ability, socioeconomic status and previous scholastic achievement in biology have no bars on the concept attainment in biology.

Likhia (1996) investigated to compare the effectiveness of teaching science through ITM and traditional method on achievement in science. The IQ was selected as co-variante. In this study, control group post test only design was used. The experimental group was taught through ITM whereas the control group was taught by traditional method of teaching. Experiment was conducted for 20 days, during which 20 lessons were taught, post test was conducted at the end. The t-test was used for analysis of data.

Findings of study reveal that Inquiry Training Model was more effective than traditional approach in teaching of science.
Sivakumar and Prema (1996) conducted a study to find out the effectiveness of Inquiry Training Model in learning biology at secondary level. The sample was comprised of 60 secondary school students who were divided into 2 groups of 30 each, one experimental and another control group. They were matched for SES and IQ by pairing. The investigator used the equivalent groups design. The experimental group was taught by using Inquiry Training Model of teaching and the control group by using conventional method of instruction. Mean, S.D. and t-tests were employed in the study for analysis of data. The study reveals that Inquiry Training Model of teaching was more effective than teaching with conventional approach. This investigation also shows that the ideas or concepts should not be forced on the students’ mind, rather concepts or ideas must be developed within mind through a natural way of scientific inquiry.

Vishwanath (2002) conducted a study to compare the effectiveness of advance organizer model (AOM) and Inquiry Training Model (ITM) on achievement of X grade students in environmental studies with that of normally practiced methods (NPM). The sample consisted of 120 students of 3 rural government high schools of udupi district in Karnataka and this sample was equally divided in 3 groups, one was taught through AOM, 2nd was taught through ITM and 3rd one was taught through NPM. He found that student taught through AOM and ITM performed better than students taught through NPM when an achievement test in environmental studies was conducted on all the 3 groups. But there was no significant difference in performance of AOM and ITM groups.

Mcbride, Bhatti and Hannan (2004) trained trainee teachers of middle and high schools located in the Rio Grande Valley of South Texas to teach through Inquiry Training Model. Teachers in the program spend approximately 45 hours of class time during the summer (2–3 weeks, 6 hour-long sessions every day), 24 hours during the fall semester, and an additional 30 hours during the spring semester (one monthly session of 6 hours each) in order to complete 99 hours of intensive training in physics concepts through inquiry training. They found that students taught by these teachers achieved more marks in their school exams than students taught by those teachers who are trained to teach through conventional methods.
Kaliya, Ashok (2005) conducted a study to investigate the effectiveness of Mastery Learning Strategy and Inquiry Training Model on the achievement of students in Science at VII Grade level. For this purpose a sample of 90 students was drawn from VII Grade students from a school at Rohtak (Haryana) affiliated to CBSE. Three groups of students each comprising 30 students were formed and were labeled as Experimental Group I (E1), Experimental Group II (E2), and Control Group (C). All the three groups were equated on intelligence using Cattell’s Culture Fair Intelligence Test. Lesson plans on Mastery Learning and Inquiry Training Model were prepared and implemented after pre-testing on Achievement Test. After completion of the instructional treatment, achievement test was administered as post-test to students of experimental Group I, Experimental Group II and Control Group. One way ANOVA and t-test were used to arrive at the following conclusions: (i) Mastery Learning Group was found to attain significantly higher achievement scores as compared to Inquiry Training Group and Control Group; (ii) Inquiry Training Model of Teaching and Traditional Method of Teaching are equally effective in raising the achievement of students in Science.

Pandey, A., Nanda, G.K., Ranjan, V. (2011) studied the effectiveness of Inquiry Training Model over conventional teaching method in teaching physical science at the secondary level of science students. A total of 100 students participated in the study. The author selected the randomized groups, pre-test post-test design under true experimental design. Results revealed that Inquiry Training Model (ITM) is more effective than conventional teaching method on Academic achievement of students. Based upon the achievement test in physical science (ATPS), teaching of physical science through Inquiry Training Model of teaching is more effective than the teaching through the Conventional Method at the secondary level.

Smitha & Manjula (2011) conducted a research study to find the relative effectiveness of two approaches of teaching (Inquiry Training Model and guided discovery learning). A pre-test post-test quasi-experimental design with a $3 \times 2$ factorial matrix was employed. 126 students belonging to three different sections of the eighth standard of a school were selected in the sample for study. Two sections, consisting of 42 students each, were selected as experimental groups in which the Inquiry Training Model and Guided Discovery Learning were applied for teaching and the third section was the control group which used conventional lecture
demonstration method. The study revealed that both teaching approaches i.e. Inquiry Training Model and Guided Discovery Learning were equally effective in developing critical thinking in students and that both these approaches were more effective than the conventional lecture demonstration method.

**Vaishnav (2013)** conducted a study to find out the effectiveness of Inquiry Training Model over traditional teaching method for Science at VI grade level. A total of 60 students were taken in the sample for study. The researcher selected the two randomized equivalent groups, each comprising 30 students & labeled them as experimental group & Control group. Students in the experimental group were exposed to treatment using Inquiry Training Model while students in the control group were taught using conventional method of teaching for Science. The pre test was administered to students in both the groups before commencement of teaching. After the teaching, a post test was administered. The data was analyzed by using t test. Result revealed more statistical significant effect of Inquiry Training Model on academic achievement of students than traditional teaching method.

**Singh (2014)** in a research study examined effectiveness of Inquiry Training Model over traditional method of teaching in teaching chemistry at IX class level. A total of 120 students were selected in the sample for the study. The study was designed to prepare study material for teaching chemistry for class IX according to Inquiry Training Model, to determine the effectiveness of Inquiry Training Model on academic achievement of students and compare the academic achievement of students taught through Inquiry Training Model & traditional method for teaching chemistry. The researcher assigned students the two groups randomly where each comprising 60 students & were labelled as experimental group & Control group. The students of control group were taught through traditional method while the students of experimental group were taught through Inquiry Training Model. The pre test was administered to students in both the groups before commencement of teaching and post test was administered after completion of teaching in both the groups. It was found that the calculated value of mean of Post test of control group is 12.55, standard deviation is 4.38 & the mean of Post test of experimental group is 17.46 and standard deviation is 5.88. Result revealed that there is a statistical significant effect of Inquiry Training Model over conventional teaching method on academic achievement of
students. It was found that the students taught with Inquiry training method performed better than the students taught with traditional method.

**Chaudhary (2015)** conducted a study to analyse effect of Inquiry Training Model on science achievement of class VIII students. 120 class VIII students of vadodara city were selected through Purposive sampling technique. control group pre test post test design was used. Inquiry Training Model was found to be more effective in comparison of traditional teaching method. Students gained a good learning experience when they were taught through Inquiry Training Model.

**Latchannna & Swarnalatha (2016)** investigated the effect of Concept Attainment and Inquiry Training Model on teaching of Biological Science at secondary level. Descriptive survey experimental research design (quasi-experimental) was used. For this study, a random sample of 175 teachers teaching Biological Science was extracted from 24 mandals of Srikakulam district. A sample of 360 students was selected randomly. These 360 students were assigned to experimental and control group in equal number. The experimental group was taught through Concept Attainment and Inquiry Training Models of teaching. Students in control group were learnt through the conventional method of teaching. The major data collecting tools used in study were questionnaire and achievement test (experimental study). The collected data was analysed by using both descriptive and inferential statistics. Qualitative analysis (by variation) was used also. The main aim of this study was to bring out the relative effect of CAM, ITM and conventional method of teaching on the achievement of students for acquisition of Biology concepts in class VIII and IX. The study revealed that there was a significant difference not only between CAM and conventional method, but also between ITM and conventional method on the achievement of students in understanding of Biological Science concepts of class VIII and IX.

**Jai Parkash and Hooda, S. (2016)**, in an experimental study investigated the Effectiveness of Science Enquiry Model, Advance Organiser Model and Conventional Method of teaching in achievement in Biology. In this research study, pre-test, experimental treatment and post-test design was used. Sample was divided into three groups of students, two experimental groups and one control group. Students in Experimental Group-I were taught Biology through Science Enquiry
Experimental Group-II was taught Biology by using Advance Organiser Model and the Control Group was taught Biology by using Conventional Method. The design comprised three stages. The first stage was pre-testing of all the students of three groups on achievement in Biology, Intelligence and Socio-Economic Status. The second stage was comprised of treatment for duration of twenty weeks. The experimental treatment included teaching of four units of Biology through Science Inquiry Model to Experimental Group-I, through Advance Organiser Model to Experimental Group-II and through Conventional Method to Control Group. In the third stage, the post test was administered on Achievement in Biology and Self-Concept. Purposive sampling was used for the research study. D.A.V. Centenary Public School, Sirsa was selected for sample. Four sections of IX class were chosen. Students of these sections were divided in to Experimental Group - I and Experimental Group - II and Control Group. Each group consisted of 60 students in each group. The Experimental Group - I, Experimental Group - II and Control Group were made homogenous in terms of Mental Ability or Intelligence and Socio-Economic Status. After equating the groups, each group had 40 students. Results revealed that the students who were taught Biology through Science Enquiry Model and Advance Organiser Model have shown more significant improvement in the Achievement in Biology than the students who were taught through Conventional Method. The group of students taught Biology through Advance Organizer Model, have shown significantly higher gain in achievement than the group of students taught Biology using Science Inquiry Model.

2.3 INTERNATIONAL STUDIES RELATED TO SCIENCE TEACHING

Dennis (1984) investigated the effect of advance organizer and repetition on achievements in a high school biology class. The sample consisted of four groups of 10th grade students. California achievement test, a Lindquist type I research design and a multivariate analysis of variance were utilized. The findings showed that there was no significant interaction between treatments on the two dependent variables. However, there was a significant gain in achievement by students in all groups from pre-test to post-test.

Lewis (1986) compared the effectiveness of Ausubelian advance organizer and simplified readability of science content when used together or separately in the
biology laboratory. The findings showed that either the advance organizer or simplified reading material was significantly better than no treatment but the two together were significantly better than either alone.

Bagget (1993) compared the relative effectiveness of using different concept map presentations as advance organizer in teaching photosynthesis to community college science students. The subjects in the study were grade III students from six intact Biology classes in a Southern Mississippi Community College. A no concept map control group and two concept maps experimental groups were utilized. The experimental design was pretest – post test multiple linear regression analysis was employed to test the hypotheses. Teaching through concept map as advance organizer was found to be superior than that of control group.

Hass (2002) in his research titled ‘The influence of teaching methods on student achievement on Virginia’s end of course standards of learning test for algebra I’ suggested that Algebra I teachers should employ proper combination of direct instruction and technology aided instruction, and problem-based learning. These three teaching method components ranked highest in the analyses. In the research six components of teaching methods and corresponding effect sizes were derived for ‘good’ studies: direct instruction, problem-based learning, technology aided instruction, cooperative learning, manipulative models, multiple representations, and communication & study skills.

Nuhoglu and Yalcin (2006) in their study entitled ‘The effectiveness of the learning cycle model to increase students’ achievement in the physics laboratory’ found that learning cycle model facilitates students to learn effectively and organize the knowledge in a meaningful order. It increases retention. Students become more capable to use their knowledge in other areas outside the original context. The learning cycle is a well-established and suitable inductive approach to learning science. This research study was conducted on 70 students and followed pre-test - post-test experimental design.

O’Day (2007) in her study ‘The value of animations in biology teaching: a study of long-term memory retention’ involving 393 students’ responses, three different animations and two graphics i.e. one with and other lacking a legend were used to determine the long-term retention of information imparted. The results show that
students retain more information after 21 days of viewing an animation without narration compared with an equivalent graphic whether or not that graphic had a legend.

**Wambugu and Changeiywo (2008)** in their study ‘Effects of mastery learning approach on secondary school students’ physics achievement’ investigated effects of Mastery Learning Approach (MLA) on students achievement in Physics. The study was Quasi-experimental and Solomon Four Non-equivalent Control Group Design was used. The target population consisted of secondary school students in Kieni East Division of Nyeri District. Purposive sampling was used to obtain a sample of four co-educational secondary schools. Each school provided two class for the study hence a total of 161 students was involved. The students were taught the same Physics topic of Equilibrium and Centre of Gravity. In the experimental groups ,students were taught with MLA teaching method while the Regular Teaching Method (RTM) was used in the control groups. The experimental groups were given treatment of MLA for a period of three weeks. The researchers trained the teachers in the experimental groups for teaching according to technique of MLA before the treatment. Pre-test was administered before treatment and a post-test after three weeks of treatment. The instrument used in the study was Physics Achievement Test (PAT) to measure students’ achievement in physics. The instrument was pilot tested to determine the reliability. The reliability coefficient was found to be 0.76. Experts determined their validity before being used for data collection. Data was analyzed by using techniques of t-test, ANOVA and ANCOVA. Hypotheses were accepted or rejected at significant level of 0.05. The results of the study showed that students in group taught through MLA teaching method scored higher achievement score but gender had no significant effect on their achievement. The researchers concludes that MLA is an effective teaching method, which physics teachers should be encouraged to employ in classroom and should be implemented in all teacher education programmes in Kenya.

**Ozden and Gultekin (2008)** investigated the effects of brain based learning on academic achievement and retention of knowledge in science course. The research study was conducted on 22 fifth grade students. Findings of study revealed that there was a significant difference was in achievement and attitude. Hence, the study suggested brain based learning for students.
Uwameiye and Ojikutu (2008) investigated the effect of team teaching on the learners’ academic achievement in introductory technology. Two secondary schools were randomly selected for sample of this study. The tool used for data collection was the Introductory Technology Achievement Test (ITAT) which consisted of 50 multiple-choice items. The findings of this study showed that there is a significant difference between the mean post-test achievement scores of students taught using team teaching and those taught in a conventional single-teacher classroom.

Chianson, Kurumeh and Obida (2010) studied the effect of cooperative learning method in comparison of conventional learning method in order to find out the students’ retention level in circle geometry. The study was conducted on senior secondary students in the three education zones (Zone A, B and C) in Benue State, Nigeria. Cooperative learning strategy was used to teach 358 senior secondary two (SSII) students circle geometry, and saw how much the learning method was effective in improving on students’ ability to retain concepts in mathematics compared with conventional learning method of teaching. An independent t-test analysis was employed to find whether a statistical significant difference existed between the cooperative learning approach and the conventional learning approach in terms of students’ retention of the taught concept (t = 8.474, df =356, p= 0.01). The findings of the study revealed that students who were exposed to the cooperative learning strategy were able to retain the concepts of circle geometry more than those students who were taught through the conventional learning approach. Hence the recommendations were that, students would be able to retain taught and learnt concepts in mathematics for a longer period of time if mathematics teachers applied the cooperative learning strategy in teaching.

Martin (2010) studied the relationship between teachers’ self-reported preparedness for teaching science content and their instructional practices to the science achievement of eighth grade science students in the United States as reported by TIMSS 2007. Six hundred eighty-seven eighth grade science teachers in the United States teaching 7377 students gave their responses to the TIMSS 2007 questionnaire about their instructional preparedness and their instructional practices. Quantitative data were recorded and analyzed through correlation analysis, the researcher found statistically significant positive relationships exist between eighth grade science teachers’ main area of study and their self-reported beliefs about their preparedness to
teach that same content area. Another correlation analysis reported a statistically significant negative relationship between teachers’ self-reported use of inquiry-based instruction and preparedness to teach chemistry, physics and earth science. Another correlation analysis revealed a statistically significant positive relationship between physics preparedness and students’ science achievement. Finally, a correlation analysis reported a statistically significant positive relationship existed between science teachers’ self-reported implementation of inquiry-based instructional practices and students’ achievement. The data findings supported the conclusion that teachers having spirit of preparedness to teach science content and implement more inquiry-based instruction and less didactic instruction high achieving science students. As science teachers gain the appropriate knowledge in science content and pedagogy, science teachers will be confident to prepare and will implement inquiry-based instruction in science classrooms.

Khan and Saeed (2010) in their study ‘Effects of teaching chemistry through concept formation teaching model on students’ achievement’ studied the effectiveness of concept formation teaching model over traditional method on Class IX students’ achievement. It was an experimental study in which concept formation teaching model was compared with traditional method. The objective of the study was to find the effects of ‘Concept Formation Teaching Model’ on the teaching of Chemistry to Class IX. For experiment, sample was consisted of 143 students in experimental groups and 147 students in the control groups. Pre-test-Post-test Nonequivalent-Groups Design was used for study. Experimental group was taught through concept formation teaching model and control group was taught through traditional method for three months. Pre-test and post-test were administered to experimental and control groups at the beginning and end of the teaching. 31 lesson plans were developed on the format of direct instruction from chapter No. 7 to 10 of Chemistry textbook for Class IX published by Punjab Textbook Board. To find the effects of concept formation teaching model on achievement of Class IX students in the subject of Chemistry, the significance of difference between the mean achievement scores of experimental and control groups was analyzed at .05 level by applying analyses of covariance. Data analysis showed that concept formation teaching model had great effect on the achievement of the students. The experimental group improved more than the control groups on post-test showing the better effectiveness of concept
formation teaching model in comparison of traditional method. Hence the ultimate results of the study revealed that concept formation teaching model was more effective as compared to traditional method.

**Deslauriers and Wieman (2011)** in their study “Learning and Retention of quantum concepts with different teaching methods” assessed mastery and retention of conceptual understanding of quantum mechanics in a modern physics course. The group of students which was taught through highly rated traditional lecturer scored 19% lower than the equivalent cohort that was taught through interactive engagement methods. However, the amount of retention was very high for both groups, showing only a few percent decreases in scores when retested 6 and 18 months after completion of the course and with no exposure to the material in the interim period. This high level of retention is in striking contrast to the retention measured for more factual learning from university courses and emphasizes for the value of emphasizing conceptual learning.

**Narli (2011)** examined the long-term effects of instructing Cantor set theory using constructivist learning approach on students’ knowledge retention. The sample included 60 first-year secondary mathematics pre-service teachers. Students were divided into two classes one of which was taught through traditional lecture (N = 30) and the other was taught through active learning approach (N = 30). A pre-test titled as “Minimum Requirements Identification Test” developed by the researcher was employed in the determination of the groups. This test involves the concepts such as “set, relation, and function” whose knowledge were required to be able to learn Cantor set theory. Student retention of Cantor set theory was assessed by using a questionnaire which consisted of open-ended questions about the topic. The test was administered to all of the participants approximately 14 months after the first instruction. In addition, interview was taken from five students from each group. Analyses of the data showed that the students in the constructivist learning environment showed better retention of almost all of the concepts regarding to Cantor set theory than the students in the traditional class.

**Ogwuche and Kurumeh (2011)** in their study studied the effect of two problem-solving models on students’ achievement in algebraic word problem. The study used a quasi-experimental design referred to as pre-test, post-test control group design. It
was limited to Education Zone C of Benue State of Nigeria. Three coeducational secondary schools were selected for the study using purposive and simple random sampling techniques. In each of the three schools selected, two intact classes were randomly drawn from the JSS III classes. The experimental groups were taught the algebraic word problem through Greeno and Metes et al problem solving models respectively, while the control group was taught the same topics through the conventional method. A total of 260 participants were selected for sample in the study. The reliability of the objective test item was computed using kuder-Richardson formula 20 which was found to be 0.93 and 0.94 for the essay questions through inter rater reliability. Two research questions were addressed by mean and standard deviation while three hypotheses were checked through ANCOVA. Data in the word problems were recorded using Mathematics Achievement Test (MAT) and the pre-test was administered in the experimental and control groups were given before the commencement of the experiment and post-tested after the experiment. The result of the study revealed that a significant difference was found in the mean scores of subjects exposed to the two problem solving models.

2.4 INDIAN STUDIES RELATED TO SCIENCE TEACHING

Tamthai (1982) conducted a study to determine the facilitating effects of a pictorial diagrammatic advance organizer on science learning achievement. The findings were (i) advance organizer model had no facilitating effect on male students who were field independent. (ii) There exist a relationship between dependent-independent cognitive style and science learning achievement.

Rajoria (1987) studied the effectiveness of Advanced Organizer Model and the traditional method for teaching science at VIII grade students. The sample consisted of 114 students of class VIII in Govt. middle school no 24, Indore. She found that the AOM was significantly superior to traditional methods in terms of achievement in science of class VIII students when the groups were matched separately in respect of intelligence and previous year achievement in science.

Grewal and Kaur (1987) conducted a study to compare the outcome of three approaches to teaching namely, the Bruner’s model, the Ausubel’s model and the traditional model, quantified on the basis of achievement scores. The finding reveals that there was a difference in the efficacy of CAM, AOM and traditional method for
learning of concepts of science. It also reveals that CAM was more effective than AOM and there is no difference in the efficacy of AOM and traditional method.

**Kaushik (1988)** conducted a study whose objectives were i) To investigate the long-term effect of written advance organizers upon the achievement of biology of ninth grade students, (ii) to study the effect of advance organizer on students of different reading abilities, intelligence and scientific attitude, (iii) to study the interaction of the study conditions, (iv) to study the relative effectiveness of study conditions on immediate ability, intelligence and scientific attitude as covariates, and (v) to study the relationship of reading ability, intelligence and scientific attitude with mean achievement scores on immediate and delayed test, respectively of other groups viz. advance organizer model, general introduction and traditional methods. The major findings were: (i) Advance organizers’ facilitated immediate and delayed learning in biology, (ii) A general introduction or an overview, generally proceeding the learning material in the lectures, lessons are text books, was of little value as compared to the advance organizer, (iii) pupils with high intelligence, reading comprehension and scientific attitude derived the greatest advantage from the presentation of an advance organizer, (iv) general students were also benefitted by advance organizer and (v) the achievement of the learners in biology was found to be highly positively correlated with their intelligence, reading comprehension and scientific attitude.

**Aziz (1990)** compared the relative effectiveness of inductive thinking model, concept attainment model and traditional models of teaching in developing concepts in chemistry at secondary stage. The result of the analysis showed that the performance of the students taught through different models was superior than the performance of the students taught through traditional approach.

**Jamini (1991)** investigated the relative effectiveness of AOM and CAM on conceptual learning efficiency and retention of chemistry concepts in relation to divergent thinking which indicated that although both AOM and CAM were effective in fostering concept learning, AOM was comparatively more beneficial in concept learning to pupil with high divergent thinking while CAM was more beneficial to pupils with low divergent thinking.

**Manocha (1991)** conducted a study to determine the comparative effectiveness of the developed textual materials of biology for class IX in terms of reception vs traditional
and reception vs selection strategies of concept attainment model. The reception strategy of CAM was significantly superior to the conventional strategy. There is no significant difference between selection and reception strategies of CAM.

**Remadevi (1998)** has applied information processing models in teaching chemistry at the secondary and higher secondary levels with respect to (a) Knowledge level of cognitive achievement; (b) Comprehension level of cognitive achievement; (c) High Intelligence categories; (d) Low Intelligence Categories; (e) Categories of high achievers on scientific attitude scale; and (f) Categories of low achievers secondary and higher secondary on scientific attitude scale. The major findings of the study were: (1) The pupils taught through IPM were found to have significantly higher achievement than those taught through CM with respect to knowledge level of cognitive achievement, comprehension level of cognitive achievement and application level of cognitive achievement at .01 level. (2) The pupils belong to high intelligence categories taught through IPM were found to have significantly higher achievement than those taught through CM. (3) The pupils belong to low intelligence categories taught through IPM were found to have significantly higher achievement than those taught through CM. (4) The pupils belonging to the categories of high achievers on scientific attitude scale taught through IPM were found to have significantly higher achievement than those taught through CM. (5) The pupils belonging to the categories of low achievers on scientific attitude scale taught through IPM were found to have significantly higher achievement than those taught through CM.

**Verma, (2001)** attempt to compare the effectiveness of mastery learning model and inductive thinking model on pupils’ achievement in science and their creative thinking abilities. The findings of the study were: (1) The group of students taught science through mastery learning model and inductive thinking model have scored significantly higher on the criterion achievement test than the group of students taught science through conventional method and the group of students taught science through inductive thinking model have scored significantly higher on the criterion achievement test than the group of students taught science through mastery learning model. (2) The group of students taught Science through inductive thinking model have scored significantly higher gain on the test of verbal creativity than the group of students taught science through conventional method. (3) The group of students taught science through inductive thinking model have scored significantly higher gain
on the test of verbal creativity than the group of students taught science through mastery learning model.

**Bhuvaneshwari (2004)** in his study ‘Effectiveness of the computer assisted evaluation package deployed in internet and intranet as measured by Tamil Nadu professional courses entrance’ found that there was significant difference in the performance of the students under the different instructional strategies in achieving mastery in subjects like mathematics, physics and chemistry.

**Sreelekha and Nayar (2004)** conducted a study to compare the achievement level between traditional method and concept attainment model with respect to knowledge objectives, understanding objectives and application objectives. The major finding was CAM was effective in improving the overall level of achievement in chemistry.

**Mehra and Mondal (2005)** studied effects of peer tutoring on learning outcomes of high school science students’ on 108 students. They established that peer tutoring exhibited greater gains in achievement as compared to those taught with traditional method.

**Sidhu and Singh (2005)** conducted a research study titled ‘Comparative study of concept attainment model, advance organiser model and conventional method in teaching of physics in relation to intelligence and achievement motivation of class IX students’. The sample was comprised of 240 students of Class IX, enrolled in Government senior secondary school, Kanganwal, Government high school, Jhuner, and Government senior secondary school, Sandaur (Distt. Sangrur in Punjab). Sample was divided into three groups (N=80 each), two experimental groups and one control group. Pre-test, Post-test control group quasi experimental design was employed. The statistical technique of three way analysis of variance (3x2x2) was used on gain scores for finding out the main effect and interaction effect of teaching techniques, intelligence and achievement motivation on scholastic achievement in physics of class IX students. There was no significant effect of various teaching techniques, intelligence and achievement motivation on scholastic achievement of students for learning of concepts in physics.

**Wanjari (2005)** investigated effectiveness of concept attainment model and inductive thinking model of teaching on IX class students’ achievement in science. The findings
showed that significant differences were observed in achievement of three groups. However concept attainment and inductive thinking model were found to have equal effect on achievement in science.

Dange, Praveen and Gangashree (2008) conducted their study entitled ‘Effectiveness of advance organizer model in relation to traditional teaching of biology’ on a sample of 41 students of two representative schools. Findings revealed that advanced organizer model was more effective on biology achievement than traditional teaching.

Jadhav (2008) studied the effect of advance organizer model on student –teachers’ teaching and its influence on the school pupil’s performance in science. The objectives were (i) To develop self- instructional material on theory, planning and evaluation of AOM suitable for Indian conditions. (ii) To analyze the Science Syllabus of Std. IX to identify the units those can be taught using AOM. (iii) To determine the Student Teachers’ teaching performance using AOM. (iv) To determine the student teachers’ performance in terms of achievement of pupils in paper-pencil tests based on different sub units in Science. The major findings were (i) The final draft of the self-instructional material was found comprehensive, self explanatory and instructive for planning and practice teaching. (ii) Out of the syllabus prescribed for std. IX, 75 sub-units were found suitable to the Advance Organizer Model (AOM). (iii) In the first two lessons the teaching performance of the conventional group was found comparatively effective in simulated situation, whereas, in the last three lessons the teaching performance of AOM and conventional groups was found equally effective in simulated conditions. (iv) The AOM group of student teachers was found more effective than conventional method group in real classroom situations. (v) The performance of AOM group of student teachers was found superior in terms of pupils’ achievement than that of the conventional group.

Mukherjee (2011) in her study “Effectiveness of concept attainment model in terms of achievement in science of class VIII”, investigated the effectiveness of concept attainment model in terms of achievement of students in science. Researcher adopted Incidental sampling method for selection of participants. Sample was consisted of 30 students from two government higher secondary schools of Indore city. Concept
attainment model was found to have good effectiveness in terms of achievement of students in science.

Sahoo (2001) conducted an experiment to compare the relative effectiveness of computer assisted instruction and instruction with advance organizers in the teaching of life science in relation to cognitive style of learners. The major findings of the study was that there is a real difference between two treatments.

Vandana and Jadhav (2011) conducted an experiment to examine the effectiveness of AOM over traditional model in the teaching of Physics of 9th grade students. They found that AOM strategy is more effective than conventional Strategy.

3.5 CRITICAL APPRAISAL

Teaching method is always key component of teaching. Understanding a concept is easy but making someone’s mind able to grasp that concept is much difficult. That's why knowledge of content comes at second position, teaching aptitude is considered to be first requirement for being a good teacher. Knowledge and training in various teaching methods is necessary for being a successful and skillful teacher.

Science as a subject is an organized body of concepts which are to our daily life. Unlike other subjects, recalling and memorizing events and facts cannot make students acquainted of concepts. Theory should be constructed within mind of learner so that it can be assimilated easily in body of previous knowledge. So teaching of science needs a perfect integration of different teaching and instruction approaches.

Inquiry and investigation are vital part of construction of scientific knowledge. Scientific knowledge can be achieved using scientific method. Imparting science concepts to students should be implemented in the order of scientific method. Students explore and go through various experiences and these experiences are converted into pieces of concept or information. So inquiry develops minds of learners to construct knowledge by themselves.

Teaching methods should be in focus of researchers in education. Since perceptions and thinking of students change with time to time, a teaching method cannot be feasible and useful for a long duration of time. Updating and improving teaching strategies is a need of time. But often it is seen that development of teaching methods
and strategies is considered to be dependent on experience. It is misunderstood that only experience can develop teachers’ skill in improving and using teaching methods. Like other aspects of education, teaching methods are also required to be more precise and effective by imposing research techniques. Area of teaching methods or strategies has been less exercised by researchers.


But Susma (1987), Raina (1994), Alam (1996) found that Inquiry Training Model was not as effective as compared to other teaching strategies.


Mostly research studies on Inquiry Training Model are of comparison type. Inquiry Training Model has not compared solely with conventional method of teaching. In most of research studies, effectiveness of Inquiry Training Model is evaluated in combination with one or more models of teaching. Only in few research studies, effectiveness of Inquiry Training Model is assessed as single strategy of teaching.
Often, it is used as mixed approach of models of teaching i.e. combination of 2 or more than two models of teaching.

Some studies on Inquiry Training Model, which are described in review or viewed by investigator, have not included proper number of participants. In some other studies, treatment was not exposed for proper time duration. Some studies did not cover proper content area. So in this study, investigator made endeavor to add valid conclusion about effectiveness of Inquiry Training Model.