CHAPTER II
REVIEW OF RELATED LITERATURE

2.1 Introduction
Reviewing the related literatures helps the researcher to understand and familiarise the past and present studies conducted in different areas. It stimulates the researcher deep into the knowledge on the selected topic.

For the present study, researcher reviewed related literature studies conducted in India and abroad from various sources (Indian Educational surveys, journals, doctoral theses, books, international dissertation abstract, university news and ERIC etc.) on Science Process Skills and Experiential Learning. The availed reviews are broadly classified into two categories (i) studies related to Science Process Skills (ii) studies related to Experiential Learning. In each category, studies are further classified based on the concept and nature of the study. The categorisations of review of literature studies are as follows

Studies Related to Science Process Skills (SPS)
- Studies conducted on instructional strategies for developing SPS.
- Studies on influence of certain variable on acquisition of Science Process Skills (Selected Variables were intelligence, SES, Parents education, creativity, gender, preferred language, sociological, cognitive, environmental and affective, adjustment, and anxiety variables).
- Studies on SPS in Teacher education.
- Studies related to construction and standardization of SPS tools.

Studies Related to Experiential Learning (EL)
- Studies on Experiential Learning (EL) in Science, science related subjects and mathematics.

2.2 Studies Related to Science Process Skills (SPS)

2.2.1 Studies conducted on Instructional Methods for Developing SPS
Adinarayana (1984) conducted a study on science teaching in primary schools a training programme. The major objectives of the study were (i) to develop competence criteria for observational investigatory and inquiry skills in pupils (ii) to determine the advantages and effectiveness of packages in terms of development of skills in pupils. Researcher prepared instructional packages for teaching through experimental method as well as the customary method. The
sample for the study was 760 pupils from semi urban and rural schools in Madurai district using stratified random sampling. Two units of the science syllabus were selected for teaching. The sample was divided into equated groups in each school on the basis of age, mental attitudes and science background test. A criterion test was developed for assessing knowledge and comprehension, observation, inquiry and investigatory skills. The major findings are as follows (i) there was a significant difference in the development of skills among the experimental group (ii) experimental groups showed significant improvement in observational skills and investigatory skills (iii) the experimental group greatly favoured science activities. (iv) performance of experimental group increased significantly in inquiry skills.

Padilla and Okay et al (1984) conducted a study on the effects of instruction on integrated science process skill achievement. In this study different patterns and amounts of instruction on planning experiments were used with sixth- and eighth-grade students. A model for generating integrated process skill lessons was used. Treatment one involved a two-week introductory unit on integrated process skills followed by one period-long process skill activity per week for 14 weeks. Treatment Two involved only the same two-week introductory unit. Treatment Three was a contrast group which received only content oriented instruction. Results showed that both sixth- and eighth-grade students learnt to use certain integrated process skills; growth was apparent in identifying variables and stating hypotheses. Differences generally favoured treatment one over treatment three.

Ganguli and Gurumoorthy (1985) conducted a comparative study on effectiveness of guided open ended approach of doing physics experiments versus traditional approach at higher secondary stage. The major objectives of the study were (i) to compare the skills in observation, classification, drawing, tabulating and computing etc., developed by students following the above two approaches (ii) to compare within the groups viz the guided open ended group and the traditional laboratory group, subgroup with respect to the acquisition of knowledge, understanding, application and development of skills and creative abilities. This was an experimental study where in the experimental group followed the guided open ended approach and the control group followed the traditional laboratory approach in the selected five topics in physics. Sample consisted of 92 students (46 in each group) selected from two colleges in Mysore
University. Tools used to collect data were achievement test, skills tests and creativity test developed by the investigator. The findings of the study revealed that (i) the students of the guided open ended group showed better performance in the achievement test and in the skills test than the traditional laboratory work. Results also revealed that the guided open ended approach was superior to the traditional lab approach in developing content matter, practical skill in physics.

Grewal (1988) Conducted a study on development, validation and tested the efficacy of self leaning process material for the development of some integrated processes in science. The integrated processes of science such as classifying, inferring, interpreting, predicting, hypothesis making and testing were taken up in the study. The sample of the study initially comprised of 390 higher secondary students from four higher secondary school of Bihar City which was finally reduced to 77. Findings of the study found that the processes like prediction and interpretation were hardly found in teaching. More commonly used processes were inferring and classifying.

Radhamonyamma (1988) studied the evolving instructional techniques appropriate to the development of various scientific skills among secondary school pupils in Kerala. The objectives of the study were (i) to list the scientific skills that can be developed through science teaching (ii) to construct an achievement test based on scientific skills (iii) to plan a suitable method for developing scientific skills. The sample for the study comprised of IX Standard students from Govt and private schools. The study was experimental in nature. The following tools were used: Observation for science teachers, Opinionnaire for teachers, achievement test in science based on scientific skills. The results was found that the achievement in science as well as acquisition of scientific skills was low, the new evolved method for teaching scientific skills through tested lesson plan was more effective than the traditional method. It was found that the new method was more effective than the ordinary classroom method for developing scientific skills. Researcher further observed during the study that pupil centred method not found in the classroom, usually written work was given in the classroom, collecting materials, making observation, reading science books and periodicals were not encouraged. Pupils remain passive listeners or observers while experiments are conducted. Pupils are not given opportunity to observe the specimens or model.
Germann (1989) investigated the effect of the directed-inquiry approach on science process skills and scientific problem solving. The sample for this study included four sections of ninth and tenth grade general biology. Students were grouped by academic ability with the experimental group consisting of average ability students and the comparison group consisting of above-average ability students. The research reported that the use of a directed-inquiry approach improved the learning of science process skills.

Rubin (1989) conducted a study by utilizing systematic modelling teaching strategy to promote the development of integrated science process skills and formal cognitive reasoning ability. The study revealed the following (i) students who have received modelled instruction demonstrated a significant difference in their achievement of process skills when compared to either of the control strategy groups (ii) students at different cognitive reasoning levels demonstrated a significantly different in process skill ability (iii) There was significant interaction between teaching strategy and cognitive reasoning level with respect to process skill ability (iv) students who received process skills instruction through different strategies demonstrated a significant difference in cognitive reasoning ability.

Roth and Choudhary (1993) examine the development of integrated science process skills in the context of open inquiry laboratory sections. The approach of study was qualitative. The results showed that students developed higher order process skills through non traditional laboratory experiences that provided the students with freedom for experiments of personal relevance in authentic context. Students learned to (a) identify and define pertinent variables (b) interpret transform and analyse data (c) plan and design an experiment (d) formulate hypothesis. The study suggests that process skills need not be taught separately. Integrated process skills develop gradually and reach a high level of sophistication when experiments are performed in meaningful context.

Sharma (1994) studied the effectiveness of an instructional programme in development of science process skills among elementary school children. The objectives of the study: to experimentally validate instructional programmes specifically designed to foster science process skills and explore the factors affecting development of process skills. The sample consisted of schools offering NCERT syllabus. The study was delimited to pupils of standard III.
studying in three CBSE schools. The experimental and parallel group design was employed. The collected data was analyzed using the ANCOVA. The finding of the study revealed that instructional programme was effective in developing process skills and achievement in science content. The home environment provides higher opportunity to children in acquiring process skills.

**Kasinath (2000)** studies the effectiveness of inquiry method of teaching in fostering science process skills, creativity and curiosity. The purpose of the study was to compare the inquiry training method and conventional method of teaching science in fostering science process skills, creativity and curiosity of the learners. A sample of 72 students of grade nine were divided into experimental and control group using intelligence as control variable. The data were collected using science process skills test, verbal test of creative thinking and curiosity test. The pre test–post test parallel design was used. The experiment was carried out for a period of three months. Two way ANOVA and ‘t’ test were employed to analysis the data. Results revealed that the Inquiry Training Method was found to be more effective than conventional method in fostering science process skills, creativity and curiosity of the students.

**Osborne (2000)** examined the effect of level of openness in agriscience experiments on student achievement and understanding of science process skills. Quasi-experimental non-equivalent control group design was employed. The sample included 150 students from 14 schools. Nearly all students in the sample were 15 or 16 years of age. The study found that the students who participated in the prescriptive laboratories developed higher levels of science process skills and achievement than those students conducting investigative laboratory exercises. However, it was also discovered that in general all the students in the agricultural education courses had very low science process skill scores as measured by the Test of Integrated Process Skills (TIPS). Osborne recommended that a follow-up study be completed to investigate the effects of learning style on science achievement and process skill proficiency.

**Krystyniak (2001)** studied the effect of participation in an extended inquiry project on general chemistry student laboratory interaction confidence and process skills. The study explored the effect of participation in extended open inquiry participation on their use of science process skills and confidence in performing specific aspects of laboratory investigation. The sample consisted of
157 second semester general chemistry students at the universities. The instrument included test of integrated process skills (T.I.P.S) and Chemistry Laboratory Survey (CLS). The ANNOVA was used to analyse the data. Results indicate that the experimental group students' showed a significant increase in science process skills. Research results indicate that the students who participated in open inquiry laboratory method increase student confidence and ability to use science process skills.

Disimoni (2002) conducted a study on writing as a vehicle to promote and develop scientific concepts and process skills in fourth grade students. The purpose of this study was to observe the impact of the use of writing on a thinking tool on the promotion and development of scientific concepts and science process skills in elementary students in the discipline of science. The study consisted of twelve fourth grade students each in the experimental and control group. Standardized tests administered to both groups to assess their basic process skills prior and after the intervention. The experimental group received the treatment and the control group did not receive any treatment. A pre-test and post test was administered. Specially designed rubric was used to evaluate and score the writing. Findings found that there was no statistical difference found in either group to demonstrate that writing affected the development of process skill.

Vijayakumari (2002) studied the effect of different methods of teaching science on the achievement, basic process skills and scientific attitude of pupils with different achievement level. The study focussed to compare the lacking processes in terms of interaction patterns associated with the teacher demonstration, guided discovery and cooperative learning methods of teaching science and final variation in interaction due to change in prior achievement levels of pupils with respect to Teacher Demonstration Method (TDM) Guided Discovery Method (GD) and Cooperative learning method (GDLM & CLM) of teaching science. Researcher randomly selected ninety six students of standard six from rural government higher primary schools. Following tools were used to collect the data: basic science process skills test by Padilla, scientific attitude and achievement test and classroom observation. Collected data were analysed by product moment correlation, ANOVA and t test. The study finding revealed that the selected method significantly improved the process skills scores.
Ramkumar (2003) conducted a study acquisition of Process Skills by IV Standard Pupils through an Instructional Programme in Environmental Studies. The main objectives of the study were to develop and implement instructional programme in environmental studies for IV Standard pupils to acquire science process skills. The instructional programme was prepared with respect to three topics (Soil, Sound and Water evaporation from 4th standard environmental Studies text book of Karnataka state Government). The methodology employed for the study was qualitative and governed by case study. Sample for the present study was a rural primary school in Karnataka selected purposively as a case study school. The data were collected through Participant observation, In-depth interviews and documentary analysis for a period of six months. The qualitative data analysis was followed by reading and re-reading the field notes, and triangulation techniques. Findings of the study presented into four assertions. Assertion One: Instructional programme in environmental studies facilitated the teacher in evolving teaching strategies for enhancing teacher-pupils interactions during the acquisition of process skills. Assertion Two: During the context of scientific investigation pupils expressed autonomy in learning through interactions with teachers and with fellow peers. Assertion three: Pupils proposed hypothesis based on certain concepts to explain the occurrence of events during the context of scientific investigation. Assertion four: Pupils showed willingness to change ideas in the light of evidence.

Myers (2004) conducted a study on the effect of investigative laboratory integration on student content knowledge and science process skill achievement across learning styles. The purpose of this study was to determine the effect of investigative laboratory integration on student content knowledge achievement and science process skill achievement across learning styles, gender, and ethnicity. The investigator employed quasi-experimental design. In this study three different types of treatment was used they are subject matter approach without laboratory experimentation, subject matter approach with prescriptive laboratory experimentation, and subject matter approach with investigative laboratory experimentation. A purposive sample was selected based upon the ability of the teacher to effectively deliver all three of the teaching approach treatments; Sample was ten different schools across Florida were selected to participate in this study. A total of 501 students were enrolled in classes in the
selected schools from which data were collected. Tools used for the study were Test of Integrated Process Skills (Dillashaw & Okey, 1980). Collected data were analyzed by descriptive and inferential statistics (regression analyses, MANCOVA, ANCOVA). The findings of the study revealed that (i) Students taught using the investigative laboratory approach recorded highest mean score on science process skill. (b) There was a significant difference in science process skill gain score among the students taught by the three approaches. (c) field-Independent learners taught using the investigative laboratory approach recorded the highest mean scores on science process skills.

Salih (2004) studied the effects of inquiry-based instruction on the development of integrated science process skills in training primary school teachers with different Piagetian developmental levels. The objective of the study was to determine whether inquiry based instruction is equally effective to develop integrated science process skills of college juniors classified as being concrete, transitional, and formal questioners. Post-scores were analyzed to compare the groups post-integrated science process skills. Analysis of pair-wise comparison among developmental levels data revealed that the students at the formal level performed significantly better than the students at both concrete and transitional levels with respect to the acquisition of integrated science process skills. Formal students show more positive responses to the instruction than concrete and transitional reasons. Study findings suggest that teachers who wish to use inquiry based instruction to teach integrated science process skills should begin implementing an additional instruction to improve students reasoning skills.

Satya Prakesh and Patnaick (2005) conducted a study on the effect of cooperative learning on development of process skills in biology. The objectives of the study were to implement co-operative learning during the teaching of biology portion of science and find out its effect on development of some of process skills. Experimental design pre-test-post test design was employed for the study. The sample of the study was 200 students of which 100 were treated as experimental and 100 were considered as control group. Both the groups were matched on the basis of intelligence as well as for achievement in biology. The main tools used for the study were process skills and achievement test in biology constructed and standardized by the researcher. Raven’s progressive matrices test used to find out the effect of cooperative learning and acquisition of process skills
in biology. Statistical tools and techniques are mean standard deviation and “t” ratio was employed. Findings (i) co-operative learning has significantly helped in improvement of different components of process skills in biology such as observation, generalization, interpretation, inference and prediction (ii) the flexible environment of the co-operative learning helped the students to observe, explore, think divergently and share ideas with their friends.

**Kanli (2007)** conducted a study to find out the effects of a laboratory based 7E learning cycle model (a type of inquiry learning) and verification of 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 control and experimental groups students. Results reveal that the use of 7E learning cycle model of inquiry based laboratory approach applications are more effective than the verification laboratory approach applications in terms of students’ science process skills and conceptual achievements.

**Feyzioglu (2009)** conducted a study on an investigation of the relationship between Science Process Skills with Efficient Laboratory Use and Science Achievement in Chemistry Education. The study was conducted using the relational survey model single-group post test design. The sample consisted of 180 students’ who took the Basic Chemistry course in a public university. Tools were questionnaire for students’ opinions on their Science Process Skills (SPS), Efficient Laboratory Attitude Scale (ELA), and Science Achievement Test (SAT). Statistical techniques employed for the present study correlation, t test, regression analysis, mean, standard deviation. Results shows that a significant and positively linear relationship was found between the reports prepared by students at the end of the laboratory classes and basic- and high-level science process skills dealt with during the laboratory applications.

**Aruna and Sumi (2010)** conducted a study on to find out the effectiveness of process approach in science on attitude towards science and process skills in science of secondary school students. One of the objectives of the study were to compare the mean pre-test scores and post-test scores of Process Skills in Science of the experimental and control group. The experimental design (pre-test post-test) was employed for the study. Sample was 35 students from standard ninth randomly assigned one as the experimental group and other as control group. The
experimental group taught by process approach and the control group taught by constructivist approach. Tools for the present study was Lesson Transcript for Process Approach Model of Teaching; Lesson Transcript based on Constructivist Model of Teaching; and Achievement Test in Biology; Test of Process Skills in Science for the Secondary School Pupils; and Scale of Attitude towards Science. For checking the initial status of science and process skills pre-test was conducted. After the treatment, post test was conducted. The statistical techniques used were: mean; Standard Deviation; and “t” test. The findings of the study revealed that the Process Approach is superior to the constructivist model of teaching for increasing Attitude towards Science, and Process Skills in Science.

**Bhaskar (2010)** conducted a study on Efficacy of constructivist approach on Science process skills learning. The objectives of the study were (i) to study the effectiveness of constructivist approach for acquiring science process skills, (ii) to find out whether there is any significance difference between boys and girls in acquisition of science process skills. The design of the study was experimental in nature where experimental and control group were employed. The investigator taught the control group through conventional method and the experimental group taught through constructivist approach for attain science process skills. The sample for the present study was 65 students from standard IX from one of the district in Tamilnadu selected purposively. The tool adopted for collecting data was science process skills test and reaction scale and collected data was analysed by “t” test and pearson’s product moment correlation. The findings of the study revealed that (i) the experimental group taught through constructivist approach performed better than the control group in science process skills test. (ii) There was a significant difference between boys and girls in their acquisition of science process skills among the students of experimental group. (iii) Students having better reaction towards constructivist approach the higher will be the attainment in science process skills ability.

**Duran and Ozdemi (2010)** conducted a study on to investigate the effects of scientific process skills-based learning approach usedin 6th and 7th grades for Science and Technology Course on the students’ attitudes towards science. Pre-test and post-test experimental design was used. Sample for the study was 6th and 7th grade students. Total 108 students were randomly assigned to control (N=54) and experimental (N=54) groups. While science teaching was conducted
according to scientific process skills-based learning approach in the experimental group, in the control group this approach was not used. The data were collected with “scale of attitude towards science” and open-ended questions developed by the researcher. The collected data were analysed through descriptive analysis and t test. Study results shows that (i) students scientific process skills-based science and technology teaching enhances students’ scientific process skills.

**Ambross (2011)** conducted a case study on development and implementation of science process skills for Grades 4 to 7 learners in Natural Sciences in a South African Primary School. The study emerged with following questions 1) how has the implementing of science process skills impacted on the Natural Sciences educator? The research methodology employed for this study was both quantitative and qualitative. Four educators (one male and three females) from Primary School participated in this study. The educators were selected purposively. Data collected by tests, questionnaires, interviews, focus-group interviews, observations as well as primary and secondary sources. Quantitative data were collected from a Science Process Skill Observation-scale and an Assessment Activity Science Process Skill Rating-Scale. Data were analysed by two methods qualitative and quantitative, qualitative data were analysed on a daily basis. The quantitative data were analysed through the computation of individual frequencies. Findings of the study revealed that concept of science process skills influenced their confidence and ability to teach science through methods of inquiry, and learners learn process skills best through a method of inquiry.

**Amin (2011)** conducted a study on development and implementation of an Activity Based Teaching Programme for pre service student teachers. The main objectives of the study were (i) to develop and implement activity Based Science teaching programme on student teachers. (ii) to study the effectiveness of the developed programme in terms of differences in student teachers with respect to a) content knowledge b) experimental ability c) understanding about the nature of science d) understanding about the science teaching. Design of the study was single group pre test post test design. Sample for the study were all the student teachers, sampling technique was purposive. Tools were achievement test, activity evaluation sheet, nature of science scale, observation, rating scale and
field notes, collected data analysed by quantitatively using t test, frequency, percentage and qualitative data analysed by content analysis. The finding revealed that (i) there is a significant difference in the score of experimental skills of the student teachers with respect to the given treatment. (ii) demonstration video playing improved students science process skills.

**Khan and Iqbal (2011)** conducted a study on Effect of Inquiry Lab Teaching Method on the Development of Scientific Skills through the Teaching of Biology. Following objectives were focused in the study: 1) to measure the effect of inquiry teaching method and traditional laboratory teaching method on the development of scientific skills among students studying biology in 9th. The pre-test, post-test equivalent group design was employed. Sample for the study was 9th standard students enrolled in the subject of biology at Govt High School, Rawalpindi, Pakistan. Tools for the study were self constructed rating scale for scientific skills, and three point rating scale for science process skills. Data analysed by t-test. Findings of the study revealed that (i) inquiry teaching lab method is more effective in developing scientific skill than traditional teaching lab method. (ii) There was statistically significant difference between post-test of control and experimental groups of scientific skills regarding observing, manipulating, classifying, drawing, measuring and communicating.

**Ergul and Simsekli et al., (2012)** conducted a study on the effects of inquiry-based science teaching on elementary school students’ science process skills and science attitudes. The purpose of this study was to investigate the effects of hands-on activities incorporating inquiry based science teaching on fourth, fifth, sixth, seventh and eighth grades students’ science process skills and attitudes toward science lessons. The design of the study was experimental design pre-test and post-test. The study sample comprised of 241 students from 4th to 8th standard. The tools used for the present study were integrated science process skills test (ISPST) and basic science process skills test (BSPST). Data were analysed by ANCOVA. Study findings revealed that (i) the students in the experimental group had a better performance in terms of BSPST and ISPST scores than the control group. (ii) Experimental group scores higher than the control groups in their process skills. (iii) Results also indicate that hands-on activities incorporating inquiry based science teaching to science instruction will improve science attitudes and science process skills.
2.2.1.1 Major Observations

Researcher reviewed twenty nine studies on the development of process skills through different instructional strategies in India and Abroad. Of the total twenty nine studies, eleven studies were conducted in India and eighteen studies were conducted in abroad. From the above studies it can be observed that some of the researchers developed and implemented packages, instructional technique, and modules or programme to enhance the process skills. Findings revealed that the implemented package, programmes, modules improved students’ observational, inquiry and investigatory skills in experimental group. On the other side some of the researchers chosen different instructional method such as inquiry approach and open inquiry laboratory method, guided open ended approach, explicit instruction, environmental based models, and 7E model, activity based approach, cooperative learning, investigatory laboratory, constructive method for developing science process skills, creativity and curiosity, and attitude (Germann, 1989; Roth and Choudhary, 1993; Ganguli and Gurumoorthy, 1985; Kasinath, 2000; Kristyniak, 2001; Salih, 2004; Myers (2004). The result reveals that the adopted method developed the process skills. Another researcher Disimoni (2002) taken up a different study on writing as a vehicle for promote concepts and process skills in science. Vijayakumari (2002) thought one step in ahead to test the effect of two or more methods in process skills development. The finding of the study revealed that selected method significantly improved the process skills scores. By observing and analysing the research studies in India and abroad most of the researcher developed both basic and integrated skills. The methodology adopted by the researchers was mostly experimental and control group pre-test and post-test, factorial design, experimental cum survey method and qualitative method. The study samples were school students. Sampling techniques was purposive, random, stratified sampling. The tools used were individual data sheet, record sheet, criterion test, achievement test, science process skills test, test of process of scientific inquiry, observations, Opinionnaire, rating scale, activity schedule, TIPS, basic science process skills test. Collected data were analysed both qualitative and quantitative methods. The finding of all the studies reveals that the adopted instructional method, package, programmes, modules increased the process skills scores than the traditional method.
2.2.2 Studies on Influence of Certain Variables on Acquisition of Science Process Skills

Bhargava (1983) conducted a study on process skills of some cognitive processes in science learning with reference to physics for students to higher secondary classes. The tools used for the collection of data were Jatota’s general mantel ability test, a battery of test of science processes observing, measuring, drawing inferences, and making predictions, hypothesis making and hypothesis testing. Statistical techniques used for analyzing the data and testing the hypothesis was ANCOVA, t test, product moment correlation, coefficient correlation and factor analysis. The major findings and conclusions of the study were (i) the scores on science process were found to be correlated with intelligence also with the components of SES. (ii) Boys were found to be superior to girls on the processes of observation, measuring and drawing inferences (iii) urban students outperformed their counterparts in rural areas on science processes.

Ramesh (1984) conducted a study on the development of objective based science curriculum and to study its efficacy in the acquisition of process skills among high school science student. The objectives of the study were to find out (i) whether the objective based curriculum was superior to the conventional curriculum of science at high school level in terms of acquisition of process skills (ii) whether intelligence contributed significantly to the acquisition of process skills among high school science students (iii) whether personality traits (Extroversion and introversion) contributed to the acquisition of process skills among high school science students (iv) whether there was significant effect of the interaction between types of curriculum and intelligence achievement and acquisition of process skills. A sample of 150 students were selected randomly from class X students from government and privately run schools of Ropar district. A 2x3x2 factorial design was followed in the study. The tools used in the study were (i) an achievement test developed locally (ii) a test to measure process skills. The Major findings of the study were (i) the mean scores of the group taught through the objective based curriculum was more effective with respect to acquisition of process skills than the traditional curriculum (ii) the above average intelligence group had higher mean scores on
the process skills test than average and below average intelligence groups (iii) the personality of the student namely and introvert did not affect the acquisition of process skills.

Khalwania (1986) conducted a study on effectiveness of concept based science curriculum in developing cognitive structures and acquisition of process skills among high school students. The objectives of the study were (i) to develop concept based curriculum to teach few important science concepts (ii) to study its efficiency as compassed to a conventional curriculum in terms of development of cognitive structures and acquisition of process skills. This was an experimental study were pre-test post test randomized group design was employed. The sample of the study consisted of 160 students divided into two groups of 80 students each. These group were assigned to two different types of curriculum viz the concept based science curriculum and the conventional one. The tools were employed in the study were (i) the Process skills test. The collected data were analyzed with the help of ANOVA. The finding of the study were (i) the concept based curriculum was more effective than the conventional curriculum in terms of acquisition of process skills as well as in developing better cognitive structures (ii) students having high self concept did not differ in process skill scores from students having low self esteem. (iii) Levels of intelligence did not affect mean scores on the process skills test.

Menon (1986) conducted a research study entitled on a system of science and the perspective of the process of science inquiry. The major objectives of the study were (i) to arrive at the norms of development of the process skill of scientific inquiry among students of secondary and higher secondary classes of the English Medium schools which followed the curriculum system framed by the Gujarat secondary and higher secondary education Board (ii) to study the overall impact of the curriculum system on the development of the process skills of scientific inquiry (iii) to examine the science textbooks for standard VIII to XII for their suitability to develop skills of scientific inquiry. Multi cross sectional survey was conducted among a sample of 1448 students of Standard VIII to XII in the Baroda. Data were collected with the help of test of process of scientific inquiry (TOPS 1) which was constructed and validated by the investigator. The obtained data were subjected to content analysis. The major finding of the study (i) the proficiency in the process skills steadily increased as student went up from
lower standard to higher standard students. There was a sudden transition in the overall development of process skills between standard X and XI (around the age of 16 years) (ii) the skills of interpreting observational data was developed around 15 years of age (iv) the children of the schools affiliated to the Central Board of Secondary Education (CBSE) were found better in the development of the process skills.

**Suresh (1991)** conducted a study on identification of certain sociological, cognitive, and environmental variables related to process outcomes in secondary school biology. Results found that parental education, parental occupation, parental income, family size and socio economic status coming under the sociological variables, intelligence and science learning approach coming under the cognitive variables, home environment for science learning and total science learning environment significantly influencing process outcomes in biology. A multiple prediction equation was also developed for predicting process outcomes using the four best predictors among the independent variables, viz.; intelligence, parental education, parental occupation and science learning approach.

**German (1994)** studied and tested a model of science process skill acquisition and intervention with parents’ education, preferred language, gender, science attitude, cognitive development, academic ability and biology knowledge. The sample consisted of 67 ninth and tenth grade biology students who lived in a rural Franco community. Path analysis techniques were used to test a hypothesized structural model of direct and indirect language effects of students’ variables on science process skills. Academic ability, biological knowledge and language preference had significant direct effects. There was a significant moderate effect by cognitive development, parents’ education towards science in school. The variables of cognitive development and academic ability had the greatest total effects on science process skills.

**Celene Joseph (1998)** conducted a study on process outcomes in physics in relation to some select cognitive, affective, social and environmental variables. Objective of the study were (i) To identify the selected independent variables cognitive affective social and environmental which influence process outcomes in physics in terms of their ability to discriminate between three levels of achievement based on process outcomes in physics (high process achievers, average process achievers low process achievers) through paired comparison
of the mean scores of these groups. Present study was conducted on a basal sample of 1000 ninth standard students of secondary schools of Kerala. Stratified sampling technique were employed which comes down to 900. Test of process outcomes in physics (TPOP), scale of attitude towards science learning SATSL, science learning interest inventories SLII were the tools used to collect data. Data were analyzed by two tailed test, Pearson product movement correlation, and multiple regression. The findings of the study were (i) all the cognitive affective and social variable correlates significantly with dependent variable (ii) the High process achievers HPA group revealed that all the independent variables cognitive affective social and three of environmental showed significant relationship with the dependent variables process outcomes in physics. All the cognitive and social variables registered positive correlation with process outcomes in physics even though they are not significant.

**Kwatra (2000)** studied understanding of science process in relation to scientific creativity, intelligence and problem solving ability of middle school students of Bhopal division. The objectives of the study were (i) to construct and standardize a test of science processes for the students of eighth grade, (ii) to evaluate the influence of scientific creativity on the understanding of science process among students of high, middle and low groups for each science process separately, (iii) to evaluate an influence of intelligence on the understanding of science process among the students of high, middle and low groups for each science process separately, (iv) to evaluate the influence of problem solving ability on the understanding of science process among students of high, middle and low groups for each science process separately. The sample comprised of 631 students selected through stratified random sampling method. Researcher computed the correlation of selected variables such as creativity and intelligence with science processes. The major findings were higher group was superior to the lower and middle group in understanding of science processes, Findings of the study also revealed that creativity and intelligence together play significant role in students understanding about basic processes of science.

**Minimol (2000)** conducted a study on process outcomes in basic science of primary school children: An investigation of certain personality correlates. Objectives of the study were (i) to identify the independent variable which influence process outcomes in basic science in terms of their ability to
discriminate between high–average, low achievers based an process outcomes in basic science through paired companions of the mean scores of these group. (ii) To identify the independent variables selected for the study which influence process outcomes on basic science through paired comparisons of the mean scores of pupils in the subsamples classified on the basis of (a) sex (b) school location (c) the type of school management (iii) To estimate the degree of relationship of each of the independent variable and process outcomes in basic science for the total samples and subsamples selected for the study (iv) to develop multiple regression equation for predicting process outcomes in basic science with the help of the independent variables used in the study. The present study has been envisaged on a sample of 600 students of standard VII drawn from 15 Schools of Ernakulum and Kottayam District in Kerala Selected by proportionate stratified sampling technique. The tools for the present study was to test of process in basic science was developed and standardized by the investigator. Collected data were analysed by following statistical tools and techniques such as two tailed test, Pearson’s product moment co efficient of correlations, percentage variance, and multiple regressions equations. The findings of the study were: (i) correlation correction between personal adjustment and POB (Process Outcomes in Basic science) was found to be significant at 0.01 level after the whole sample. (ii) correction between social adjustment and POB for all subsamples was found to be significant at 0.01 level (iii) correlation between examination anxiety and POB for all subsample was found to be significant at 0.01 level (iv) correlation between achievement motivation and POB for all subsamples was found to be significant at 0.01 level. (v) Correlation between science interest and POB for all sub samples was found to be significant at 0.001 level.

Minikumari (2002) conducted a study on the effects of intelligence, adjustment and anxiety on process outcomes on science of secondary schools children. Objectives of the study were to asses separately the possible influence of each of the independent variables selected for the study or process outcomes in science for total samples and relevant sub samples. Sample for the present study was 800 students studying 1X standard. Proportionate stratified sampling techniques were employed. The following Statistical techniques such as Product moment correlation, ANCOVA, test of significance were used to analyze the data.
Findings of the study were (i) Intelligence exert a significant influence and process outcomes in science i.e. higher the intelligence higher will be their achievement in science process. Curriculum provides very little scope for developing various process skills. Instructional practices should be revitalized giving children enough scope for developing various processes of science such as observing measuring experimenting and drawing inferences. The study also reveals that the ability of urban pupils is superior to that of rural pupils in science process skills, so more training for the development of various science process skills must be given to rural pupils.

**Department of Education, University of Lousiana at Moular (2004)** conducted a study on “The effect of an integrated activity based science curriculum on students’ achievement, science process skills and attitude towards science”. The design of the study was experimental. Integrated curriculum was used in experimental group and traditional science curriculum used in control group. Sample for the study was seventh grade students. Iowa test of basic skills, science process skills test are the tools employed for data collection. Collected data were analysed by ANCOVA. The results showed that the experimental group students had a significantly higher achievement post test mean compared to the students in a traditional science programme.

**Jaiman Jacob (2004)** conducted a study on effects of deficit in scientific skills achievement in science of the learning disabled at the primary school level. The objectives of the study were (i) To study the difference between the normal and learning disabled children as well as language learning disabled and mathematics learning disabled with respect to their science process skills. (ii) To study the difference between boys and girls of the normal and learning disabled with respect to their science process skills achievement in science and intelligence. A normative survey method was adopted and the sample for the study consists of 614 primary school children from Kottayam District in Kerala. The tools used for the present study were science process skills test, test of achievement in science. Test of significance, Pearson product moment coefficient of correlation ($r$) are the statistical techniques used for data analysis. Major findings were (i) the mean scores of process skills test scores of LD and ND children were found to be significant. The Higher mean value of ND children is indicative of the fact that they are superior to LD children in the case of science process skills (ii)
Significance difference was found between language LD and ND with respect to science process skills. The higher mean value shows that language ND children are superior to language LD children with respect their science process skills. (iii) comparison of the mean scores of science process skills test showed that there is significant difference in the science process skills of mathematics LD and LD students and higher mean value indicates that mathematics ND Children are better in their science process skills compared to mathematics LD Children (iv) there is no significant difference between boys and girls with respect to the science process skills.

Dokme and Aydinl (2009) conducted a study to determine if: (a) some Turkish elementary school student’ level of performance on a test of basic science process skills is satisfactory or not; and (b) there is any statically significant difference in students’ performance on the test of basic science process skills linked to their gender, grade level, economic background, the education background of their mother and the number of family. The main study sample comprised of 670 students (230 sixth grades, 239 seven grades, 201 eighth grades including boys and girls). The sample students randomly selected from five state elementary schools. In this study data were collected by basic science process skills test constructed by the researcher. The collected data were analysed by each sample students’ score on the basic science process skills test are calculated and computed variance (ANOVA) analysis. The findings shows that (i) there is a statistically difference in the students’ performance on the basic sciences processes skills test linked to their grade level. The means of the seventh graders was much higher than the others. However the means of the eighth graders was lower than the seventh graders. (ii) There is statistically significant difference in the students’ performance on the basic sciences processes skills test linked to the education background of their mother and the number of family.

2.2.2.1 Major Observations

From the above studies, it can be observed that there were thirteen studies were conducted in the area of influence of variable on SPS both India and abroad, out of thirteen studies, ten studies were conducted in India and three studies were conducted in abroad. Some of the researcher (Bhatt, 1983; Bhargava, 1983) made attempt to test the influence of selected independent variable on process skill development. The results indicate that the understanding of process skills
depends upon their Socio Economic Status i.e. higher socio economic boys scored better than middle and low SES. Study findings also revealed that process skills acquisition is correlated with intelligence, SES, and gender. Boys’ superior to girls on processes of observation, measuring and drawings inferences. On the other side, few researchers (Ramesh, 1984; Menon, 1986; Minikumari, 2002) focussed on influence of curriculum and certain variables for process skills development. The research finding reveals that objective based curriculum more effective in acquiring process skills than traditional one. Also, acquisition of process skills depends on intelligence and creativity that is higher the intelligence higher will be their achievement in science process. Khalwania (1986) study findings reveal that high economic status and high self concept students increases the process skills scores. Similarly, Suresh (1991) study finding reveals that sociological, cognitive and environmental variables influence the process skills development. Study finding also shows that cognitive, affective and social variables significantly influence the process outcomes (Celene Joseph, 1998).

By observing the above studies, researchers adopted different methodology and designs such as pre-test, post test design, factorial design, normative survey method. The samples were ranges from the standard of sixth, seventh, eighth, ninth, tenth and higher secondary students includes both boys and girls, and sampling techniques employed were simple random, stratified random, proportionate stratified random sampling. The following tools were employed battery test on process skill, process skills test, TOPS. The collected data were analysed by using description statistics and inferential statistics, ANOVA, t test, product moment correlation, co efficient correlation, path analysis techniques (German, 1994), two tailed test, multiple regression (Minimol, 2000). Findings reveal that sociological, psychological, environmental and cognitive factors influence the process skills acquisition.

2.2.3 Studies on Science Process Skills in Teacher Education

Strawitz and Malone (1987) conducted a study on pre-service teachers' acquisition and retention of integrated science process skills: A comparison of teacher-directed and self-instructional strategies. The purpose of this study was to compare the effects of two methods of instruction designed to teach pre-service elementary teachers to acquire and retain integrated science process skills. In one section instruction was provided by the teacher, whereas in the other section,
instruction was provided by written self-paced self-instructional materials. Findings indicated that the self-instructional method was significantly more effective than the teacher-directed method. Both treatments produced long-lasting retention effects.

**Scharmann (1989)** conducted a study on developmental influences of science process skill instruction. The intent of this study was to examine the purported influence and developmental nature of a science process during a given semester of study as well as over extended curricular sequences. Data were collected from 135 elementary pre-service teachers enrolled in science teaching methods courses at the endpoint of one of three sequences: (a) introductory process instruction with three subsequent semesters of integrated science content and teaching methods, (b) process instruction with separate subsequent content and teaching methods, and (c) only science content with subsequent teaching methods. Statistical procedures included Kruskal-Wallis ANOVA and Wilcoxon tests. Results indicated that a one-semester process skills course was influential in developing a basis for science content acquisition and in fostering an understanding of the nature of science.

**Lobo (1990)** studied the effect of developing science process skills among pre-service secondary teachers on their classroom behaviour. The objectives were to study the effectiveness of a specially designed teaching or training programme and developing process skills, and to study the effectiveness of the developed programmes at cognitive and performance level. The sample consisted of 32 pre-service physics teachers in experimental and control group. ANCOVA was employed to analyse the data. The results indicated that the experimental group performed significantly better than the control group with regard to acquisition of process skills. The experimental treatment was relatively more effective than the control group. Treatment brought change in teacher attitudes towards science and science teaching.

**Foulds and Rowe (1992)** study conducted on the enhancement of science process skills in primary teacher education students. The purpose of this study was to determine the extent to which the science education units promote the development of science process skills. The sample of the study was both first and second year students of Edith Cowan University. First and second year students were given a pre-test at the beginning of their science education units and post-
test at the ends of the units. The treatment consisted of the normal laboratory activities of classes and assignments used across the two courses. Collected data analysed by two tailed T-Tests. The findings were the first unit of science education statistically significant gains in all three science process skills, also suggesting that the course was an effective aid to process skill development. In the thirteen months between the two units subjects showed some decline in the science process skills measured. The declines were not statistically significant, thus it suggesting that the effects of the treatment are persistent. During the second unit in science education students again showed significant improvement in their process skills. These gains effectively recovered the losses that occurred in the time between the two units.

**Letsholo and Yandila (1995)** conducted a study on to find out if teachers employed the process skills in the classroom situation. a) Are pupils able to demonstrate the acquisition of certain process skills as they tackle various tasks in class? b) Are materials used in science classroom appropriate and adequate enough to facilitate the learning and teaching of process skills? Researcher followed a survey type study and the sample constituted 27 teachers and 27 classes with 38 pupils each. Five schools were randomly selected and in each school two classes were also randomly selected. Tools used for the present study were (a) A classroom observation technique schedule and (b) Teacher's questionnaire. Data collected by the Individual teachers and all pupils in their classrooms. The data were analysed by frequencies and percentages, and questionnaire responses analysed descriptively. The finding of the study reveals that observation is highest while the skills of recording and communication ranked second highest. The results also indicated that the teachers used the skill of observation by the magnitude of 31.9% followed by the skill of recording and communication with 26.7%. The skill of hypothesising was used by 7.8% magnitude, measurement 6.5% Interpretation 5.9% and Raising questions by 0.6%.

**McCain (2005)** conducted a qualitative study of pre-service teachers using co-teaching as a method to understand scientific process skills to teach inquiry. The purpose of this naturalistic inquiry project was to examine the perceptions of Pre-service teachers as they learn and implement co-teaching strategies to enhance their understanding of inquiry-oriented teaching by using science process skills.
The class used in this study consisted of 24 pre-service students—21 female and 3 male. Data collected from the participants through an open-ended method, Interviews, reflective journals, and autobiographical journals to understand how the participants developed an understanding and perceived process skill instruction and co-teaching. The collected data were analyzed using an analytic induction method, hermeneutics. Findings revealed that the pre-service teachers were able to describe the use of the process skills. Participants mention that the process skills are useful in life with something as mundane as a recipe. Also pre-service teachers said that process skills are great importance to students. The pre-service teachers agree that process skill instruction is crucial in an elementary science classroom.

Miles (2008) conducted a study on in-service elementary teachers’ familiarity, interest, conceptual knowledge, and performance on science process skills. The purposes of this research study was to determine (a) in-service elementary teachers’ familiarity, interest, conceptual knowledge of, and performance on science process skills and (b) how in-service elementary teachers’ familiarity with, interest in, conceptual knowledge of, and performance on science process skills relate to each other. Sample consisted of 24 in-service elementary teachers.

Instrument used for this study were science process skills questionnaire, interest scale on science process skills, science process skills performance test. Data was analyzed and examined using descriptive statistics (mean values and percentages), Mann-Whitney U test, t-test, one-way analysis of variance (ANOVA). Results indicate that the teachers significantly have higher interest in learning more about the integrated process skills than basic process skills, and teachers most familiar with the skill experiment but inferring skills was least familiar. The skill in which teachers performed the most poorly was graphing. Teachers also performed poorly on observation and controlling variables.

Duran Isik et al., (2011) conducted a study on the relationship between the pre-service science teachers’ scientific process skills and learning styles. The purpose was to determine the relationship between the pre service science teachers’ scientific process skills and their learning styles. The method was a survey. The study was carried out with 151 1st and 4th year students attending Science Teacher Education, Department of Education, and Faculty at Muğla University. The pre-service teachers’ learning styles were determined through “Kolb Learning Style
Inventory” and “Scientific Process Skills Test” developed by Burns, Okey and Wise (1985) to determine the scientific process skills of high school and university students. To determine pre-service teachers’ science process skills score means in relation to their learning styles, descriptive statistics is used, and One Way ANOVA was used. The findings of the study reveals that that (i) science pre-service teachers prefer learning by doing, they are successful in problem-solving, logical analysis, and decision making, and moreover, they prefer to use detailed, sequenced, and planned information. (ii) In relation to learning styles, when SPS scores of science pre-service teachers are compared, it was seen that the mean SPS score of the students having separating learning style is higher than those of the students having the other learning styles.

2.2.3.1 Major Observations

It can be observed from the above studies that there were eight studies reviewed in this area of SPS in Teacher education. Out of eight studies, one study was conducted in India (Lobo, 1990) and seven studies were in abroad. In order to develop process skills among students’ teachers, researcher used different methods such as laboratory method, co teaching methods, training programme was employed by researchers (Foulds and Rowe, 1992; McCain, 2005). Research findings indicate that the developed programme and the implemented methods significantly improved the process skills and it brought changes in teachers’ attitudes towards science and science teaching. Miles (2008) Study finding reported that teachers have more interest in learning basic process skills than the integrated skills. From the above literature studies it can be observed that the researchers used pre test and post test experimental design, survey method, qualitative studies. Samples were pre-service physics teachers and in-service elementary teachers, and primary teacher education students. Tools and techniques used for the studies were classroom observation technique schedule and, Teacher's questionnaire, Interviews, reflective journals, and autobiographical journals, and science process skills questionnaire. Collected data were analysed by qualitatively and quantitatively techniques. Results evidenced that the training programme and laboratory activities, co teaching method, and natural inquiry method are effective strategy for process skills development.
2.2.4 Studies related to Construction and Standardisation of SPS Test

Dillashaw and Okey (1980) conducted a study on development and tested an instrument to assess the science process skills associated with planning, conducting, and interpreting results from investigations. The instrument was first field tested with samples of approximately 100 students from each grades 7, 9, and 11 in two schools. Revisions were made and the instrument was field tested with a sample of over 700 students from the same grade levels as the first test. This instrument was designed to develop a measure of integrated process skill achievement. Results indicate that the developed tool found to be a valid and reliable to measure science process skill achievement.

Bhatt (1983) conducted a study on cognitive appraisal of the processes of eighth grades students with special reference to the central schools. The objectives of the study were (i) to construct and standardize a test of science process for the students of eighth grades (ii) to compare the understanding of various processes at the eighth grade (iii) to evaluate the sex difference in the understanding of science processes (iv) to evaluate the socio economic influence on the understanding of science process. Sample for the present study was 750 eight grade students from central schools of utter Pradesh by adopting stratified random sampling techniques. Science process skill test was used to collect data. Collected data were analyzed by the both descriptive and inferential statistical techniques such as mean median standard deviation correlation, ANOVA. The findings of the study reveal that (i) following pairs of skills such as classifying and quantifying; classifying and inferring of science processes were found significant. (ii) the difference between the means scores of observing and measuring; observing and inferring; observing and predicting; comparing and measuring; classifying and measuring; classifying and predicting were found to be significant. (iii) Significant difference between the mean score of boys and girls was significant only for the process observing. (iv) the mean scores of boys were higher than that of girls for the pairs of high, middle and low socio economic status groups of both the sexes.

Germann and Aram (1996) conducted a study on student performances on the science processes of recording data, analyzing data, drawing conclusions, and providing evidence. The study was conducted to develop research rubrics for a
performance assessment of science processes and to evaluate seventh-grade science students' ability to perform them. A total of 364 students’ field tested the alternative assessment of science process skills. Their responses were used to develop a research rubric and then this rubric was used to determine response patterns that could inform both instruction and assessment of science process skills. Findings reveal that 61% of students performed the activity and recorded data successfully. Sixty-nine percent of students did not attend to draw the conclusions

White (1999) studied the development of a content influenced process skills instrument for general biology. The process of the study was to develop biological process skills test for use in college level freshmen biology classes. The study was conducted in two phase. Phase 1 was the development of process skills test, phase 2 of the study was to administer the study and determine student acquisition of process skills and to determine whether any relationship existed between acquisitions of process skills. Testing was implemented with a sample of 135 students enrolled in general biology. The process skills test and attitude towards science test were administered as pre- test and post- test. The majority of the test questions were found to be acceptable. The tests for dependent sample showed significant increase in process skills, student attitude towards science from pre test- post test. The multiple regression analysis revealed no significant relationship between process skills, student’s attitude towards science and student learning style.

Smith and Welliver (2006) conducted a study on the development of a science process assessment for fourth-grade students. In this study, a multiple-choice test entitled the Science Process assessment was developed to measure both basic and integrated science process skills. 61 items were identified for inclusion into the Science Process Assessment item bank. After established the content validity into a panel of science educators, 55 test items were acceptable. Pilot 1 was administered to 184 fourth-grade students. Pilot 2 (Test 1 and Test 2) was administered to 113 fourth-grade students. The results of this study indicate that (i) the Science Process Assessment is a valid and reliable instrument applicable to measuring the science process skills of students in grade four (2) using educational workshops as a means of developing item banks of test questions is viable and productive in the test development process (3) involving classroom
teachers and science educators in the test development process is educationally efficient and effective.

**Vikas (2009)** conducted a study on development of a performance test in chemistry for assessing the process skills of students of standard VIII. Objectives of the study were (i) To standardize a performance test in chemistry for assessing the process skills of students of standard VIII (ii) to construct items that do not favour any particular participants belonging to different gender, school type and locale. Sample for the present study were 479 students of standard VIII of Kerala following the state syllabus. Stratified sampling technique was adopted. Tools used for the present study were (i) performance test in chemistry for assessing the process skills of students of standard VIII (ii) Evaluation proforma for teachers for assessing the performance test, evaluation of performance for pupils for assessing the performance test. Collected data were analyzed by the following Statistical techniques mean, standard duration, percentiles, two tailed test of significance and ANOVA. Findings revealed that (i) The performance test prepared and standardized by the researcher is a valid and reliable means of measuring the process skills of students of standard VIII of Kerala state (ii) The students in the high performance group had higher percentage of performance scores than the average performance group of students whose percentage scores was in turn higher than that of the students in the low performance group in all the different performance sub test.

**2.2.4.1 Major Observations**

In the area of construction and standardisation of tools, it can be observed that there were six studies were conducted in this area, out of six studies, two studies were conducted in India (Bhatt, 1983; and Vikas, 2009), rest of the four studies were conducted in abroad, (Dillashaw and Okey, 1980; White, 1999). The test was constructed to measure the basic and integrated process skills. The sample for the study were seventh, eighth, and ninth and eleventh standards (Dillashaw and Okey, 1980; White (1999; Vikas (2009). The design was experimental and control group pre- test and post- test design. Statistical techniques employed for the study: multiple regression analysis, performance test in chemistry, evaluation of performance for pupils. Results reveal that the constructed test was
educationally efficient and effective, also found to be a valid and reliable to measure of science process skill achievement and status of process skills.

2.3 Studies on Experiential Learning (EL)

2.3.1 Studies related to Experiential Learning in Science and Mathematics

Mabie and Baker (1996) conducted a study on to explore the impact of two types of agriculturally-oriented experiential instructional strategies on science process skills. The objective of the study was to ascertain whether participation in experiential instructional strategies would increase the science process skills of the students. A total of 147 students from fifth and sixth grades participated in this study. The data collection approach was qualitative in nature. Science process skills were observed both prior to the study and after the study. The findings of this study indicated that agriculturally-oriented experiential activities positively impact the development of science process skills. Also study revealed that participation in experiential activities assisted students in their ability to observe, communicate, compare, relate order and infer.

Hitz and Scanlon (2001) undertaken a study on academic achievement of students participating in a course directed by various experiential education methods versus those students taking a non-experiential, more teacher-centred course. The study was conducted over a three month period of time where 10th grade students were instructed by project based experiential learning method use in the Agricultural and Environmental Education programs. In this study some students were taught through the project based method and others through more traditional methods of classroom teaching. The finding revealed (i) students in the traditional teacher-centred classroom scored higher on unit tests right after taking the test, however, more importantly is that the students in the experiential group showed a prolonged understanding of the subject matter. (ii) Finding also revealed that experiential learning not only helps for students’ greater retention, but more positive attitude toward learning.

Shrivastava (2002) conducted a study of learning styles of secondary school students with scientific attitude and their achievement in science. The objectives of study were: (i) To study the learning style and scientific attitude of students. (ii) To study the relationship between scientific attitude and achievement in
science in relation to their learning style. The Research design was Ex – Post Facto in nature. The sample comprised of 500 Science Students of Class XI from 10 different school of Lucknow City. It was selected through Purposive Random Sampling Technique. Tools used to collect data were Learning Style Inventory by D.A. Kolb (1976), Scientific Attitude Scale, Achievement test in Science. The data were analyzed by computing Mean & SD. The findings of study were: (i) the most popular learning style of the students is accommodative learning study and second popular learning style is convergent. (ii) Most of the students with more scientific attitude prefer the convergent and accommodative learning style. (iii) The students following convergent learning style score better in science than the students following other learning styles. (iv) The students with more scientific attitude score better in science than the students possessing less scientific attitude. (v) The convergent learning style is most appropriate style whereas assimilative learning style is most inappropriate for learning science.

Arnold and Warner et al., (2006) conducted a study on experiential learning in secondary agricultural education classroom. The objectives of the study were (i) to determine agriculture teachers knowledge and familiarity with experiential learning in a secondary agriculture classroom (ii) describe how agriculture teachers use the Kolb’s model of experiential learning in their classroom (iii) determine the self perceived role of the teacher when using experiential learning in an agriculture education classroom. A qualitative approach was utilised to explore the use of experiential learning in agriculture classroom. Sample for the study were four agricultural education teachers selected purposively. The tools and techniques were semi structured interviews conducted with the participants. The collected data analysed by qualitatively using triangulation method. The findings of the study reveal that experiential learning offers quality experience, active engagement, reflective observation, and application useful for comprehensive understanding of knowledge and skills. Teachers commented that experiential learning requires to change their way of thinking and allows students an opportunity for self discovery learning. Also teachers recognised that multiple benefits of experiential learning including increased subject matter retention among students, active engagements.

Gordon (2006) conducted a study on the importance of adding science process skills and hands-on science experiences in the pre-k classroom. This action
research study examined the impact of the integration of science process skills and developmentally appropriate hands-on science experiences on student readiness skills for kindergarten within the pre-kindergarten High/Scope daily Routine. The sample for the project was Miami-Dade County Public Schools Voluntary Pre- Kindergarten (VPK). Tools used for this research project were the Phonological Early Learning Inventory pre and post tests (PELI) and the Learning Accomplishment Profile Diagnostic (LAP-D) pre and post subtests. Qualitative Data was collected from teacher lesson plans, the teacher’s reflective journal, student’s work, and daily key notes (anecdotes) used in the High/Scope Program. Data were analysed by mean and percentage. Findings shows that many parents made unsolicited positive comments on the interest, the students were showing at home in observing and classifying objects as the child would explore materials in the home environment. Integrating science process skills and developmentally appropriate “hands-on” science activities in a pre-k classroom does not only improve student readiness skills for kindergarten but improves emotional and social skills as well.

Parmer (2006) conducted a study on the effects of an experiential learning model of education on second grade students. This study sought to address the relationship between gardening as an experiential learning process, and fruit and vegetable knowledge, preference and consumption behaviour in an elementary school aged population. A total of 115 second grade students participated in the study. Participants were selected using a non-randomized, convenience type sampling method. The participants of this study took part in horticulture classes and gardening work experience 16-week period. Data were analyzed using SPSS, A mixed model ANOVA, t tests, Post- hoc tests, chi-square test. Findings of the study revealed that horticulture knowledge and environmental attitudes improved as a result of experiential learning and gardening experience. School gardens as an experiential learning increase fruit and vegetable knowledge, preference and consumption among children. These findings suggest that school administrators, classroom teachers and nutrition educators should work closely together to implement school gardens to allow for hands on learning opportunities as a way to influence dietary habits at an early age.

Aboukinane (2007) conducted a qualitative study of creative thinking using experiential learning in an agricultural and life sciences course. The purpose of
this study was to explore whether creativity can be nurtured in an experiential learning environment at the college level. The study sample was 14 participants who consisted of mostly incoming freshmen, rest being sophomores, juniors, and transfer students. Qualitative approaches were used while observing students. Data collected through all four sources (field notes, focus group interview, questionnaire and portfolios). Data were analysed by qualitatively. Findings indicated that both (i) process-based and construct-based creativity models are good indicators of creative behaviour. (ii) all steps of the process based creativity model were fully utilized in the experiential and team-based learning environment. (iii) Creativity can be fostered through experiential and team-based learning.

Davis (2008) conducted a case study on science professional development program based on Kolb’s experiential learning model. The purpose of this case study was to investigate how three science teachers who participated in the Rivers to Reef professional development course interpreted the learning experience and integrated the experience into their teaching practice. Descriptive qualitative case study was conducted over the course of 4 months. Three middle school teachers were selected from a purposeful sample process. Observation and Interviews were the primary tools used in the acquisition of data. Data analysed qualitatively. Major finding of this study indicates that the years of teaching experience of middle school science teachers significantly influenced by experiential learning for their professional development, what and how they learn from the experience, and the ways in which the experience influences their teaching practices.

Huckestein (2008) conducted a study on Experiential Learning in School Gardens and Other Outdoor Environments: One of the objectives of the study was to create a plan for developing and implementing supplemental experiential learning programs in environmental science. A self-administered online survey was used to inquire about the use of experiential teaching methods using school gardens and other outdoor environments. The survey was sent to 273 K-5 science teachers in Virginia. The researcher chose to create the electronic survey instrument. The survey questions were primarily closed-ended questions and few open ended questionnaire. The responses were analysed by both frequencies and percentages. The findings of the study indicated that most common hands-on
activity used by the science teachers for growing plants from seeds through experiential learning. Also this activity was most commonly used by fourth-grade teachers.

Beasley (2010) conducted a study on comparison of experiential learning activities available to juniors and seniors in secondary agriscience education and science education courses. An ex post facto or causal comparative research design was used in this study. A cluster sampling of schools with agriscience programs yielded a sample of 20 schools. The sample included 23 agriscience teachers, 35 science teachers, and 909 students. Data collected through questions related to formal and informal learning environments, another question inquired about service learning projects. Data were analysed by descriptive statistics including means, standard deviations, frequencies, t-test. Findings of the study revealed that approximately 58% of science teachers reported that service learning projects under experiential learning activities was more enjoyable in agriscience courses and science courses. Depending on the teaching methods used by the agriscience and science teachers, the majority of the activities could have been experiential learning activities.

Gafoor and Narayan (2010) conducted a study out of school experience and Interest in science of upper Primary School pupils of Kerala. The major objectives of the study (i) to find out the extent of out of school science experiences and interest in science of upper primary school pupils and the gender and locale on out of school science experiences (ii) to find out whether there is significant relationship between out of school science experiences and interest in science. The sample was 1461 upper primary pupils selected from 14 schools of Kozhikode district in Kerala followed stratified random sampling technique. The tools used for the present study were scale of out of school science experiences (SOSSE) and scale of interest in science. Findings of the study reveal that out of science experience of upper primary pupils was found to be moderate in nature: extent with pupils deriving comparatively more experience from biology than from physics and chemistry. Pupils derived more biology experience from collection than observation. In case of physics, observation contributed more to out of schools experience and experimentation contributed the least. Similarly in chemistry too pupils conducted more observation and less experimentation. Significant gender difference existed in the extent of out of school science
experiences with boys having more experience than girls did. Out of school physics experience was more for boys while the extent of out of school biology experiences and out of school chemistry experiences exhibits no gender difference.

**Geist (2010)** had undertaken a curriculum development project on an experiential kindergarten science curriculum engaging students in the scientific inquiry process. In this curriculum, students explore through inquiry and practice the following basic skills: observation, communication, and measuring, classifying, predicting, and inferring. Researcher interest is integrating animals (frogs and butterflies) into the classroom as a learning tool guided this process. 23 students participated in this study. During explorations and activities students practiced science skills. To assess student’s progress a researcher developed rubric for teachers, which focuses on individual student’s inquiry practices during each lesson. The findings through observations revealed that students interestingly engaged and excited about what they were doing; also implementing this curriculum with this kindergarten classroom was very informative, and curriculum provided quality experiences for students.

**Mehra and Kaur (2010)** conducted a study on effect of Experiential Learning Strategy on Enhancement of Environmental Awareness among Primary School Students. The objectives of the study were: (i) To compare the mean gain on environmental awareness of the students taught through different instructional treatments (experiential Learning strategy and traditional method). The design of the study was 2x2x2 factorial design (pre test and Post test). Experimental group students’ were exposed to experiential learning strategy and the students of the control group were taught the same topics by traditional learning method. The sample for the study was 120 students of IVth class of two schools of Ropar. Tools used for the study instructional materials 50 lesson plans, and environmental awareness test comprised of 132 items, and locus control test comprised of internal and external scale. Data were analysed by using percentages, means and SDs, and ANOVA. The findings of the study revealed that the students taught EVS by experiential learning strategy exhibited better environmental awareness than those taught by traditional learning method. Experiential learning helped to enhance awareness of the pupils regarding a
particular subject and also to build their actual beliefs by real hands on experience.

**Varghese Cheriyan (2010)** conducted a study on effectiveness of Kolb’s experiential learning model on achievement in mathematics of students at secondary level. The objectives of the study were (i) to find out the achievement in mathematics of students taught using Kolb’s experiential learning model and activity oriented model. (ii) to compare the achievement in maths of students taught using Kolb’s experiential learning model and activity oriented method with respect to their learning style. The study was experimental in nature, pre test and post test non equivalent experimental and control group design. The sample used for the present study was 326 students of standard IX from eight divisions of the four secondary schools. The tools were used to collected data are lesson transcripts based on Kolb’s experiential learning model of teaching (prepared by investigator), lesson transcripts based on activity oriented method of teaching (prepared by the investigator, Kolb’s learning style inventory, ravens standard progressive matrices, achievement test in mathematics, mathematics interest inventory. The collected data were analysed by mean, t test and ANCOVA. The findings of the study revealed that (i) majority of the students belongs to accommodating and diverging learning style (ii) the achievement in mathematics of students taught using Kolb’s experiential learning is significantly higher than that of activity oriented method (iii) the mathematics interest of students taught using Kolb’s experiential learning model is significantly higher than that of those taught using activity oriented method. The Kolb’s experiential learning model found better than the existing activity oriented model among boys and girls.

**Driscoll (2011)** conducted a study on Graduates’ perspectives regarding the impact of the integration of experiential learning in academic programs. The objectives of this study were (i) to determine the impact of experiential learning program on career/graduate school. (ii) To determine the influence experiential program on career development and decidedness; and (iii) to investigate the extent to which the experiential program enhances career/graduate school preparation. This study was a descriptive survey type research, and an electronic questionnaire was chosen. Data analysed by descriptive analysis procedures, standard deviations and excel and SPSS. The findings of the study revealed that student learning, and experiential learning had a positive impact on the
development of their skills and abilities. The results indicated that the programs were able to positively enhance career/graduate school preparation by helping the participant’s transition from undergraduate student to employee/graduate student. The findings also revealed that the respondents preferred real-world, hands-on experiences.

Mulkerrin (2012) conducted a study on the effect of a zoo-based experiential academic science program on high school students’ math and science achievement and perceptions of school climate. Pre-test-post-test two-group comparative efficacy design was employed. The sample for the present study was 11th-grade and 12th-grade students who participated in a zoo-based experiential academic high school science program (n = 18). Sampling technique was random. The data on achievement of science were collected from the beginning and ending of programme, referenced achievement test proficiency scores for math, and reading were also utilised to evaluate student achievement gain and programme effectiveness, school climate as measured by ending of program school perception survey. Collected data were analysed by mean, standard deviation t test, ANOVA. Results indicated that (i) students’ who completed the Zoo-Based Academic High School Experiential Science Program had statistically greater score compared to students’ who completed the School-Based Academic High School Experiential Science Program. Findings of the study also revealed that the Zoo-Based Academic High School Experiential Science Program and the School-Based Academic High School Experiential Science Program have shown a positive impact on student academic achievement and have proven to equally prepare students for post secondary success.

2.3.1.1 Major Observations
With regard to studies on experiential learning in science and branches of science, and mathematics, there were sixteen studies reviewed in India and abroad. Out of sixteen studies, four studies were conducted in India (Shrivastava, 2002; Varghese Cheriyan, 2010; Mehra and Kaur, 2010; Gafoor and Narayan, 2010), and remaining twelve studies were conducted in abroad. Researchers employed agriculturally-oriented experiential instructional strategies, experiential education methods versus non-experiential teacher-centred method, and hands on experience to develop knowledge and skills (Mabie and Baker, 1996; Arnold and Warner et al, 2006; Hitz and Scanlon, 2001; Gordon, 2006). Findings reveal that
experiential learning improved the process skills such as observe, communicate, compare, relate order and infer. Also useful for comprehensive understanding of knowledge and skills; Study findings further reveals that experiential learning change the way of thinking and promote creative thinking, creativity, and improves achievement in science. Varghese Cheriyan (2010) study results indicate that Kolb’s experiential learning model improves significantly in mathematics achievement and interest towards mathematics among boys and girls. Mehra and Kaur (2010) study findings revealed that students taught through experiential learning method shows better environmental awareness than traditional methods. Geist (2010) study results reported that students were very much engaged and excited through experiential curriculum. The finding of Cronin (2011) reveals that science vocabulary and science process of understanding increased significantly through experiential learning method among adults.

Research design used by the researchers were pre-test and post-test experimental design, descriptive qualitative case study, qualitative, ex-post facto (Hitz and Scanlon 2001; Srivastava, 2002; Aboukinane, 2007; Varghese Cheriyan, 2010; Davis, 2008). The data were collected by both qualitatively and quantitatively by using following techniques such as teacher lesson plans, the teacher’s reflective journal, student’s work, and daily key notes (anecdotes), field notes, focus group interview, questionnaire and portfolios. The sample selected by the researchers were Pre- Kindergarten, second grade, fifth, sixth, ninth, tenth grade students and eleventh, higher secondary science background students, agricultural education teachers, middle school teachers, and the sampling techniques employed for the studies were stratified random, purposive, convenience (Mabie and Baker, 1996; Hitz and Scanlon, 2001, Arnold and Warner et al 2006; Parmar, 2006; Davis, 2008). The collected data were analysed both quantitatively and qualitatively, and mixed model analysis of variance (ANOVA). The study findings revealed that the experiential learning improved knowledge, skills, and creativity.

2.4 Implications of the related literature for the Present Study

For the present study, seventy two studies were reviewed on science process skill and experiential learning in India and abroad. Out of seventy two studies, fifty six studies related to on science process skills (twenty four studies in India and thirty
two studies in abroad) and sixteen studies related to experiential learning (four studies in India and twelve studies in abroad). Of the fifty six studies on science process skills, twenty nine studies (eleven studies in India and eighteen studies in abroad) were on development of process skills through implementation of programmes, packages, and different teaching learning strategies which are as follows

- activity based approach
- experimental method and customary method
- open ended approach versus traditional approach
- inquiry based and open inquiry laboratory approach
- laboratory methods
- self learning material
- environmental based models and environmental approach
- 7E learning cycle model
- investigatory laboratory
- cooperative learning method
- combination of Teacher Demonstration method, Guided Discovery method and cooperative learning method
- constructivist approach

The above instructional methods were employed by different researchers and studied its effectiveness in terms of enhancement of process skills. Finding shows that the selected methods significantly improved process skills.

Apart from teaching learning strategies, studies were conducted on influence of certain variables on process skills acquisition. There were thirteen studies reviewed in this area (ten studies in India and three in abroad). The researchers selected following variables such as intelligence, SES, school location, adjustment and anxiety, gender, parents’ education, preferred language, cognitive, affective, social and environmental variables (Bhargava, 1983; Kwatra, 2000; Minikumari, 2002; Jaimon Jacob, 2004; Khalwania, 1986; German, 1994; Celene Joseph, 1998; Minimol, 2000; Dikme and Aydinl, 2009). Study results revealed that the above variables influenced the acquisition of process skills among school students.

By realising the need and importance science process skills, researchers conducted studies in pre-service and in-service teacher education. Researcher
employed different instructional methods for developing science process skills in
teacher education. There were eight studies reviewed in this area. Of the eight
studies, one study in India (Lobo, 1990) and seven studies were in abroad. The
findings of the studies revealed that the selected method was effective (Foulds
and Rowe, 1992; McCain, 2005).

Process skill assessment is another important aspect in science process skills
domain. It is to be assessed with the help of appropriate tools and techniques. By
considering the importance of process skill assessment, researchers conducted the
studies on construction and standardisation of science process skills tools. There
were six studies reviewed in this area. Out of six studies, two studies conducted
in India (Bhatt1983; Vikas 2009) and four studies conducted in abroad). The
findings reveal that the developed tools were valid and reliable to assess students’
process skills. Of the fifty six studies on science process skills, more studies (i.e.
twenty nine studies) were conducted in the area of development of process skills
through different strategies compared to other areas such as variable influences
(thirteen studies), teacher education (eight studies), development and
standardisation of science process skills tools (six studies).

Coming to examine the studies on experiential learning, researcher reviewed
sixteen studies in the area of experiential learning in science and its related
subjects, and mathematics. From this observation it was observed that the
researchers adopted experiential learning method to develop interest, attitude,
knowledge and skills, and creativity Mabie and Baker (1996); Arnold and Warner
et al (2006); Hitz and Scanlon (2001);Gordon (2006); Parmer (2006); Bindu
(2007); Aboukinane (2007); Cheriyan (2010); Mulkerrin (2012); Driscoll (2011);
Huckestein (2008); Geist (2010). Study findings reveal that experiential learning:
enhanced process skills, helps the students to understand knowledge and skills,
improved emotional and social skills, developed environmental attitude, fostered
creativity, improved achievement in mathematics and science, develop
environmental awareness and subject interest, increased science vocabulary and
process of understanding, and allows students an opportunity for self discovery
learning. Of the sixteen studies on experiential learning, twelve studies were
conducted in abroad and only four studies were conducted in India which are
related to mathematics achievement, science interest and environmental
awareness (Shrivastava, 2002; Cheriyan, 2010; Mehra and Kaur, 2010; Gafoor
and Narayan, 2010). It shows that the number of studies on experiential learning was very meagre in India; also researcher did not come across any study on process skills development through experiential leaning.

Coming to educational surveys in India According to Ganguli and Vashistha (1991) in their trend report on research in science education for the past four surveys pointed out various weakness of science education. Ganguli and Vashistha (1991) listed one hundred and one studies in eight areas which were conducted during the first four surveys covered a period of fourteen years from 1974-1988 including their own research. This would suggest around seven studies per year. He stated that the “frequency of researches conducted over the first four surveys was just meagre a mere of one hundred and one studies. It is really speaking a dismal picture considering the vastness of the country”. Vaidya (1997) reported a total of sixty one studies during the period covered by the fifth survey (1988-1992). The annual average increased from 7-12 from the period of fourth to fifth survey. According to sixth survey a total of hundred and twenty studies in science education were recorded. The total number of studies almost doubled from 61 to 120 and the annual average has increased from 12 to 15. For the present study, researcher reviewed past six educational surveys, it is observed that various researchers were used observational approach, the practical approach, the problem solving approach, inquiry approach, the project method, environmental approach, a combination of method then they compared with traditional approach but the present researcher did not notice any study on process skills development through experiential learning. Vaidya (1997) reported that more studies are needed on the acquisition of scientific skills (process skill) and interests. Chunawala (2006) Sixth survey (1993-2000) stated that there is a growing acceptance among the science education reformers that processes of doing science should not be separated from scientific content and science education. Number of methods and approaches has been evolved, tested and modified but which one is most appropriate, effective, efficient and interesting method or approach, it can be answered only through research. In this view, experiential learning method is a student centred, it encourages students’ autonomy, and it enriches students’ active involvement. By keeping all these view in mind, researcher chosen experiential learning approach to develop basic Science process skills among the students of standard eight.
This chapter described in detail with regard to research trends in India and abroad related to Science process skills and experiential learning. The research studies presented in this chapter also gives the knowledge of methodology adopted by various researchers and the findings. Based on that, implications were derived for the present study. Next chapter deals with the methodology adopted for the present study.