CHAPTER VI
SUMMARY AND IMPLICATIONS

6.1 Introduction
Science is a way of knowing. It is often portrayed as a major intellectual pursuit of truth. Science has been the key to transform in every field of human endeavour throughout this century and it remains the key for the betterment of Human welfare. Science is an essential means of meeting society’s needs for food, water, energy, health care, shelter, safety and alleviation of poverty. The purpose of science is to develop knowledge scientifically. Scientific knowledge governed by observations, experimentation, verifying the prediction, testing the hypothesis, communicating, deriving inferences, etc. These are the processes encompassed in the Nature of science (NoS). Scientist follows the above processes for searching the knowledge. These processes are associated with mind and sense organs. The knowledge created through processes is reliable, verifiable and subjected to modify. NoS define the processes and products of science. To become scientifically literate, students must understand the NoS. National Science Teachers Association (NSTA, 1982) position statement clearly indicated that the importance of understanding the NoS is a critical element of scientific literacy. NCF (2005) also noticeably argued about NoS in a following way “Science is a dynamic, expanding body of knowledge covering new domains of experience, and scientific knowledge is generated through scientific method, it involves several interconnected steps: observation, looking for regularities and patterns, making hypotheses, verification or falsification of theories through observation and controlled experiments, and thus arriving at the principles, theories, and laws governing the physical world.
A product is an organised, systematised body of verified knowledge about the natural phenomena. Process is method of doing science, it includes several interconnected skills. These skills are developmental in nature therefore students needs to be practiced. Science teaching should stress more on these process skills. Padilla (1991) points out that the process skills should be taught because “it accurately reflects the nature of science and the typical activity of scientist” also he argues that activities based on the process skills provide students an approach to view the true NoS through the preparation of a scientist. Process skills
instruction is an effective method for linking the nature of science concepts, and significantly increases the understanding of science content (Scharmann, 1989; Rillero, 1998, 2007). By considering the importance of process skills, it was recommended by commissions and committees to develop science process skills upto standard X. But it is unfortunate that science teaching largely dominated by content, process skills are neglected by the teachers. It was stated by NPE (1986) that pupils are expected to develop the skills required to operate ordinary laboratory/science equipments and to design simple experiments to seek and final explanations for natural phenomena. Simple experiments and hands on experiences are the hallmark for learning concepts and process skills. Meaningful learning occurs when the learners engaged in experiments and activities. Learning as the key to personal development and experience is the key for meaningful learning. Science can be best learned by one’s own experience by doing experiments, and investigation etc. Science teaching should give opportunity to acquire knowledge and skills through direct hands on experience. Learners’ involvement and active participation are the prime principle of experiential learning. By looking at the importance of experiential learning in science researcher developed and implemented experiential learning intervention programme for developing basic science process skills among the students of standard eight, and studied to what extent the implemented programme was effective in terms of acquisition of science process skills.

6.2 Statement of the Problem
Acquisition of Science Process Skills through Experiential Learning in Students of Standard VIII

6.3 Objectives of the Study
1. To study the existing status of Science Process Skills among the students of standard VIII.
2. To develop an intervention programme based on experiential learning to enhance Science Process Skills
3. To implement the intervention programme among the students of standard VIII to enhance Science Process Skills.
4. To assess the acquisition of Science Process Skills after the intervention programme.
6.3.1 Research Questions
1. To what extent science process skills have been developed among students?
2. How effectively science process skills can be developed among students?
3. How far it is feasible to assess the developed science process skills?

6.3.2 Hypotheses
1. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of observation skill in Students of standard VIII.
2. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of classification skill in Students of standard VIII.
3. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of communication skill in Students of standard VIII.
4. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of measurement skill in Students of standard VIII.
5. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of prediction skill in Students of standard VIII.
6. There will be no significant difference in the observed and expected frequencies between pre and post intervention programme with regard to acquisition of inference skill in Students of standard VIII.
7. There will be no significant difference in the mean scores of pre test and post test with regard to achievement on basic process skills in Students of standard VIII.

6.4 Explanation of the Terms
Science Process Skills: Science Process Skills are broadly described as a set of transferable abilities or skills which are employing by scientist and students during science experiments, investigation and activities. These skills are classified into two types – basic and integrated. Basic Science process skills are observation, classification, communication, measurement, prediction and inference. Integrated Science process skills are formulation and testing of hypothesis, manipulating variables, defining variables operationally, designing and experimentating, identifying the cause and effect. For the present study researcher selected only Basic Science Process Skills (BSPS).
**Experiential Learning:** For the present study, it refers that the students construct the scientific knowledge and skills by engaging cognitively, affectively, and behaviourally in direct hands on learning experiences individually or in group. The direct hands on learning experience can be inside or outside the classroom.

**Intervention Programme:** For the present study, it is a scheduled programme developed by researcher by taking the contents of Tamilnadu State board science textbook of Standard VIIth for developing BSPS in Students of Standard eight. The programme included various learning experiences such as Hands on Experiences, Role Play, Demonstration, Field visit, Multimedia presentation (Virtual Class Experience), and Simulations which follows Kolb’s Experiential Learning Cycle. Students engaged in these learning experiences individually or in group in one academic year for acquiring BSPS.

**6.4.1 Delimitation of the Study**
- The present study was delimited to Gudalur Government Higher Secondary School situated in Gudalur Taluk, Nilgiri District, Tamilnadu.
- The study was delimited to English medium students studying during the academic year 2011-12.
- Present study was delimited only to basic science process skills.

**6.5 Methodology**

Methodology of the study contains sample and sampling technique, sources of data, tools and techniques for data collection, design of the study, and data analysis.

**6.5.1 Sample and Sampling Technique**

Sample for this study was students of standard eight (English Medium) from Gudalur Government Higher Secondary School situated in Gudalur Taluk, Nilgiri District, Tamilnadu. Purposive sampling method was adopted. The sample comprised of 28 students (7 Girls and 21 Boys).

**6.5.2 Sources of Data**

Data pertaining to basic science process skills obtained from Students of standard eight. Data related to school profile obtained from Headmaster; data with regard to effectiveness of experiential learning intervention programme in terms of acquisition of science process skills was collected from sampled students, teachers, parents and siblings of sampled students.
6.5.3 Tools and Techniques Employed for Data Collection

To collect the data on science process skills the following tools and techniques were employed.

1. Situational test for students
2. Open ended questionnaire for students
3. Closed ended questionnaire for students
4. Rating scale for students
5. Observational technique by researcher to observe student behaviour
6. Semi structured interview with students, and parents and siblings
7. Focussed Group Discussion (FGD) with Teachers
8. Video graphy and still photography

6.6 Design of the Study

Developmental cum experimental design was followed in this study. Developmental refers that researcher developed basic science process skills among the students in one academic through experiential learning intervention programme; and experimental refers that to what extent implemented programme was effective in terms acquisition of basic science process skills. The design of the study was conducted in three phases which are as follows,

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The descriptions of each phase are as follows

6.6.1 Phase I: Study the Existing Status of BSPS before Implementation of Intervention Programme

In order to collect the data on status of science process skills, situational test, open ended questionnaire, closed ended questionnaire, rating scale, semi structured group interview, participant observation, video graph and photograph are the tools and techniques were employed in the students of standard eight.
6.6.2 Phase II: Development and Implementation of Intervention Programme

In this phase, the intervention programme was developed based on Kolb’s experiential learning cycle and implemented in students of standard VIII to develop basic science process skills. The development and implementation of intervention programme described below.

6.6.2.1 Development of Intervention Programme

- Prior to develop an intervention programme, researcher analysed the contents of Tamilnadu State eighth standard science textbook, all the activities and experiments are included in the intervention programme; in addition to that, some of the experiments and activities also taken from other science source books. Hence, contents of science were chosen as the medium for developing process skills.

- The selected experiments and activities have been listed under different learning experiences such as Hands on Experience, demonstration, role play, field visit, simulation, and multimedia presentation (virtual class) which follows Kolb’s Experiential Learning Cycle.

- Then the developed programme was sent for validation and it was validated by experts. After validation, the programme was finalised to implement in the academic year of 2011-2012. Meanwhile, Tamilnadu state school education introduced new revised Science Curriculum entitled on “Common Curriculum”(Samacheerkalvi) in the year of 2011. According to new syllabus (Common Curriculum) changes were made in the intervention programme in terms of inclusion of experiments/activities. Then the revised intervention programme was implemented in the academic year 2011-2012.

The detail description of implementation of programme is as follows.

6.6.2.2 Implementation of Intervention Programme

- Developed programme was implemented in the month of August 2011 to February 2012.

- During the period of implementation of Intervention Programme regular science teacher was not intervened in teaching science and other activities. The programme was implemented, and the entire science syllabus also taught by researcher.
The sample consists of twenty eight students and they were divided into six groups. Number of students in each group was five, but in one group number of students were three.

Group wise students engaged in the following learning experiences such as hands on experience, simulation, role play, demonstration, multimedia presentation (virtual class experience) and field visit which followed the Kolb’s experiential learning cycle. Each student in a group actively participated in learning process and acquired science process skills. In each stage of the Kolb’s cycle, students acquired the science process skills.

6.6.3 Phase III: Assess the Basic Science Process Skills after Intervention Programme.

In order to know what extent the Intervention Programme was effective in terms of acquisition of basic science process skills, the following tools and techniques were employed,

1. Open ended questionnaire for students
2. Closed ended questionnaire for students
3. Rating scale for students
4. Participant observations by researcher to observe student behaviour
5. Photography and video recording
6. Semi Structured Interview with sample and non participants
7. Semi structured Interview with Parents and Siblings
8. Focussed Group Discussion with Teachers

6.7 Data Analysis

Mixed method of data analysis was employed. Quantitative data collected through closed ended questionnaire was analysed by Paired t-test. Data collected through rating scale was analysed by chi square (2x4 contingency). Data collected with the help of open ended questionnaire was analysed by frequency percentage with the help of analytic rubrics. Data collected through FGD, semi structured interview, and observations were analysed by qualitatively.
6.8 Major findings

6.8.1 Status of BSPS before Intervention Programme

- Findings with regards to status of science teaching, it was found that, students seldom visited the laboratory. Most of the time students listened to science teacher lecture wherein teacher read and explain the science concept and definitions. The teacher very rarely demonstrated the experiments in the classroom and students did not do any science experiment in classroom or laboratory on their own either in group or individually.

- The students did not operate microscope, had not observed any preserved specimens of plants and animals, and chemicals in the laboratory. Also they did not use equipments and apparatus such as magnifying lens, and simple pendulum experiment, pipette, burette, measuring cylinders, thermometers to measure the objects and liquids.

- 8.25% students’ observation skill was in proficient stage wherein students skilfully used their sensory organs and observed all similarities and differences between similar pictures. They noticed the colour, nature, appearance and texture of chemicals. They also observed the fine details of specimens of plants, animals and sand with the help of hand lens. They skilfully operated microscope and observed the human blood slides.

- 4.36% students’ classification skill was in proficient stage wherein things, substances, organisms correctly classified under correct classification based on the nature of substances, similarities and differences, common features, and similar attributes. For example, students classified magnetic and non magnetic, metals and non metals, conductors-insulators, acids and bases, pure and impure substances, hydrophytes, mesophytes, xerophytes, vertebrates and invertebrates, reptiles and amphibians, herbivores, carnivores and omnivores.

- 8.82% students’ communication skill was in proficient stage wherein students correctly plotted the line graph, bar graph, pie chart, tabular column and systematically displayed the data. They skilfully communicated through symbols and diagram.
13.88% students’ measurement skill was in proficient stage wherein students accurately measured the length, breadth, and height of the object. Exact volume of water measured correctly with the help of measuring cylinder. Weight of the object was measured correctly by using pointer balance. Students skilfully measured exact 75ml KMnO₄ solution in the measuring cylinder and 20ml of water using pipette. The temperature of water was measured accurately by using thermometer and length of curved line diagram was also measured accurately by them.

6.23% students’ prediction skill was in proficient stage wherein students’ correctly predicted the future events and occurrences based on the observations and experiences. They could give correct reasons for their predictions. For e.g. students correctly predicted ice cubes floats in water and (ii) castor oil and kerosene do not mix with water.

3.57% students’ inference skill was in proficient stage wherein students’ correctly and completely derived inference(s) based on observations of pictures, experiments, demonstration and videos. They were able to differentiate inferences and observation.

6.8.2 Acquisition of BSPS during Intervention Programme

It was found that students were actively involved in each stage of Kolb’s experiential learning cycle by doing science experiments and activities and acquired process skills.

It was observed that students skilfully operated the apparatus and equipments such as microscope, pipette burette, measuring jar, weighing balance, simple pendulum and magnifying lens.

It was observed that students constructed the science concepts through process skills which reflected their concept clarity.

Students actively involved in preparing models and teaching aids with the help of waste materials. They presented it in the class and science exhibitions. These learning experiences developed students’ presentation skill, thinking skill and their creativity.

Hands on experience, field visit, multimedia presentation, role play, simulation, and demonstration are the learning experiences improved basic science process skills via Kolb’s experiential learning cycle.
6.8.3 Status of BSPS after Intervention Programme

- 69.86% students’ observation skill was in proficient stage wherein students observed similarities and differences. Fine details of specimens were noticed. Students skilfully operated the microscope and hand lens during observation.
- 84.14% students’ classification skill was in proficient stage wherein students’ attained proficiency in classifying the things materials substances and organisms into different groups based on similar properties and characteristics.
- 62.05% students’ communication skill was in proficient stage wherein students correctly and completely plotted line graph, bar diagram, pie chart, tables and symbols and they skilfully drew diagrams.
- 73.80% students’ measurement skill was in proficient stage wherein students accurately measured the length, breadth, height, angle, area, temperature, and weight of the given diagram.
- 57.33% students’ prediction skill was in proficient stage wherein students correctly predicted the events, occurrences based on the evidences obtained through observations of experiments and past experiences. They also given correct reasons for their predictions.
- 70.75% students’ inference skill was in proficient stage wherein students correctly and completely derived all inference(s) based on observations of experiments, demonstration, pictures and videos and they able to differentiate between observations and inferences.

With regard to acquisition of observation skill, it was found that there has been a significant difference in the observed and expected frequencies between pre and post intervention programme. Hence the proposed null hypothesis Ho1 is rejected and it can be inferred that the intervention programme was effective in terms of acquisition of observation skill.

With regard to acquisition of classification skill, it was observed that there has been a significant difference in the observed and expected frequencies between pre and post intervention programme. Hence the proposed null hypothesis Ho 2 is rejected and it can be stated that the intervention programme was effective in terms of acquisition of classification skill.
With regard to acquisition of communication skill, it was found that there has been a significant difference in the observed and expected frequencies between pre and post intervention programme. Thus, the null hypothesis Ho 3 is rejected. From this it can be inferred that the experiential learning intervention programme was effective in terms of acquisition of communication skill.

With regard to measurement skill, it was observed that there has been a significant difference in the observed and expected frequencies between pre and post intervention programme. Hence, the null hypothesis Ho 4 was rejected. It can be inferred that the intervention programme was effective for the acquisition of measurement skill.

With regard to acquisition of prediction skill, it was found that there has been a significant difference in the observed and expected frequencies between pre and post intervention programme. Hence, the null hypothesis Ho 5 was rejected. It can be inferred that the intervention programme was effective in terms of acquisition of prediction skill.

With regard to acquisition of inferences skill, it was found that there has been a significant difference in the observed and expected frequencies between pre and post intervention programme. Hence, the null hypothesis Ho 6 was rejected. It can be said that intervention programme was effective in terms of acquisition of inference skill.

With regard to achievement of basic science process skills, it was found that there has been a significant difference between pre and post intervention programme. The difference was that the mean score found to be higher in post test (33.33) as compared to the pre test (9.42). Hence, it can be inferred that the experiential learning intervention programme improved students’ achievement of basic science process skills.

With regard to teachers’ opinions towards experiential learning, teachers opined that experiential learning intervention programme provided concrete learning experiences for the students to acquire knowledge and process skills.

With regard to students’ opinion towards experiential leaning intervention programme, the learning experiences such as hands on experience, multimedia presentation, group work, field visit, simulation, demonstration, laboratory visit and role play developed basic science process skills and science concepts.
The Parents and siblings opinion regarding hands on experience, field visit, role play, multimedia presentation was that these are the learning experiences beyond traditional lecture method of teaching, it de-emphasis the rote memorisation of concepts, and also develops interest towards science. It is very useful in their later stage of education.

6.9 Implications of the Present Study

Following Implications can be drawn from this study and this may bring considerable changes from school teachers to the policy makers.

- The study findings evidencing that process skills cannot be developed through traditional chalk and talk method of teaching. Hence experiential mode of learning should be employed.
- Proficiency of science process skill not only assists the students to construct basic concepts in science but also it helpful to understand the abstract concepts of science in later stage of education.
- Concepts constructed by the students through science process skill cannot be forgotten and it increases the permanence of learning.
- Acquisition of process skill helps the students to become scientifically literate persons, and they apply these skills in daily life situation.
- Basic science process skills such as observation, classification, communication, measurement, prediction, and inference are the foundation for acquiring integrated process skills such as identifying and controlling of variables, formulation and testing of hypothesis, making definitions, conducting experiments etc.
- Science process skills are the basis for developing scientific inquiry, scientific thinking, intuitive thinking, scientific attitudes and interest towards science.
- Experiential learning de-emphasis the memorisation of concepts because students actively, enthusiastically involved in experiments by their own.
- Experiential learning improves students’ sense of responsibility in learning, it increase the self autonomy, equip the students in the process of inquiry, and inquisitiveness.
- Through Experiential learning students learnt to make models by using waste materials.
The study findings suggest to the teachers that, learners are the prime importance in the learning process, and teachers are the facilitators for knowledge construction and skill acquisition.

Students employ the science process skills for learning other subjects.

By employing science process skill, students modify the existing ideas in science.

Process skills acquisition helps the students to remove the any misconception in science.

Learning does not end with our formal education, learning to be continuing throughout an individual life as a lifelong learning. Through experiential learning intervention programme students acquired the basic science process skills, and these skills play a crucial role for their lifelong learning.

Science process skills promote independent thinking, problem solving ability, intelligence, questioning skill, curiosity and divergent thinking skills.

6.10 Suggestions for Further Research

Each piece of research work gives insight to other researcher for further investigation. This study suggests certain areas to investigate further which are as follows,

More research is needed on acquisition of integrated science process skills through experiential learning.

Research is also needed in the area of acquisition of both basic and integrated science process skill through experiential learning by taking large sized samples.

Further research needed to explore by taking all other grades and geographical area.

Further study needs to conduct in the area of acquisition of science process skills in other subject too.

Research and development is needed to study the effectiveness of experiential learning in science and other subjects.
6.11 Recommendations

- Teachers need to emphasis more on process aspects of science than the product of science i.e. products of science should not be ignored; it is to be constructed through process of science.
- Process skill cannot be developed through chalk and talk method, therefore teachers need to engage the students in different learning environments and learning experiences such as experiments, activities, field trip, multimedia theatre, role play, demonstration, group discussion and investigations etc inside and outside the classroom for developing basic process skills, and promote interest and attitude towards science.
- Teaching of science should be based on experiential mode of learning.
- Process skills and products of science should not be taught in isolation. It should develop through integrated manner in such a way that students acquire process skills and concepts simultaneously.
- It is very essential that schools should have adequate equipment facilities and laboratory facilities for the students to carryout experiments and activities regularly so that students employ their sensory organs and enhance the process skills effectively.
- Teaching of science should provide opportunity for the students to use science equipments such as microscope, magnifying lens, simple pendulum etc.

6.12 Conclusion

Science is a body of knowledge and process of inquiry. Science teaching in school plays important role constructing knowledge and process skills, and attitudes. Process skills are more important than the products. Process skills are foundation for the development of all domains in science. If process skills are nurtured among the students at early stage, they develop knowledge, skills and attitude. Process skills cannot be developed through chalk and talk method. Hence, simple experiments, activities and hands on experiences should be used in the teaching learning process. Lecture method needs to be replaced by experiential mode of learning in science for constructing knowledge and process skills. Actual experiences take more time but understanding and interest are increased as a result of experience.