ACQUISITION OF SCIENCE PROCESS SKILLS THROUGH EXPERIENTIAL LEARNING IN STUDENTS OF STANDARD VIII

A

Thesis submitted to

The Maharaja Sayajirao University of Baroda, Vadodara for the

Degree of

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DECLARATION

I Ramesh M, hereby declare that the research work contained in this thesis entitled **'Acquisition of science process skills through experiential learning in students of standard VIII'** *is my own work and it has not been previously submitted for any degree or diploma in any University.*

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CERTIFICATE

This is to certify that the research work contained in this thesis entitled ***"Acquisition of science process skills through experiential learning in students of standard VIII"*** *submitted by Mr. Ramesh M to The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat for the degree of Doctor of Philosophy in Education is a record of bonafide original work conducted by him under my supervision and guidance. It is further stated that, as per the O. Ph .D.: 3 of The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat he has fulfilled the attendance criteria. I find it fit for submission and evaluation.*

Prof. R. C. Patel
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June, 2014
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ABBREVIATIONS

AAAS : American Association and Advancement of Science
ABL : Activity Based Learning
AEE : Association for Experiential Education
ALM : Active Learning Methodology
BSCS : Biological Sciences Curriculum Study
BSPS : Basic Science Process Skills
CABE : Central Advisory Board of Education
CBA : Chemical Bond Approach
CHEMSTUDY: Chemical Education Material Study
COPES : Conceptually Oriented Programme in Elementary Science
DPEP : District Primary Education Programme
EL : Experiential Learning
ELT : Experiential Learning Theory
ERIC : Education Resources Information Centre
ESS : Elementary Science Study
ESSP : Elementary School Science Project
GER : Gross Enrolment Ratio
HBCSE : Homi Bhabha Centre for Science Education
HPP : Harvard Physics Project
HSTP : Hoshangabad Science Teaching Programme
ICAR : Indian Council for Agricultural Research
ISPS : Integrated Science Process Skills
ISR : India's Science Report
MDG : Millennium Development Goals
MINNEMAST: Minnesota Mathematics and Science Teaching Project
NCAER : National Council of Applied Economic Research
NCERT : National Council of Educational Research and Training
NCF : National Curriculum Framework
NCFTE : National Curriculum Framework for Teacher Education
NCS : National Council for Science
NER : Net Enrolment Ratio
NKC : National Knowledge Commission
NoS : Nature of Science
NPE : National Policy on Education
NRC : National Research Council
NSPR : National Science Policy Resolution
NSTA : National Science Teachers Association
PoA : Programme of Action
PROBE : Public Report on Basic Education
PSSC : Physical Science Study Curriculum
RMSA : Rashtriya Madhyamik Shiksha Abhiyan

S&T : Science and Technology
SAA : Science for All Americans
SAPA : Science: A Process Approach
SCIS : Science Curriculum Improvement Study
SEP : Science Education Programme
SFA : Science for All
SPR : Scientific Policy Resolutions
SPS : Science Process Skills
SSA : Sarva Shiksha Abiyan
SSCP : School Science Curriculum Project
TIFR : Tata Institute of Fundamental Research
UGC : University Grants Commission
UK : United Kingdom
UNESCO : United Nations Educational, Scientific and Cultural Organisation
UNICEF : United Nations International Children’s Emergency Fund
US : United States
WSP : Warwick Process Science

CHAPTER I
CONCEPTUAL FRAMEWORK

1.1 Introduction

The word Science derived from Latin word Scientia which means “to know”. In this context, science is a human enterprise through which we come to understand the biological and physical aspects of the world around us. Science is tied to nature. Explanations of nature are always open to questions. Science is built from curiosity, experience, analysis, and finally the expression of discovery. Adinarayana (1977) said science is better suited than any other subjects for acquiring the ability to develop scientific attitudes, to distinguish on the fact from opinion. It is important that science is highly creative and dynamic in nature by which man can attempt to search knowledge. Science provides opportunity for an individual to develop inquiry skills, critical thinking, creativity, problem solving, decision making skills etc. National Research Council (NRC, 1996) rightly stated that Science is a Human endeavour that relies on reasoning, insight, energy, skill, and creativity. Science not only inculcates knowledge and skills to the human, it also promotes universal values to people for the betterment of society (Patel, 1997).

It was stated by NRC (1996) and American Association and Advancement of Science (AAAS, 1989; 2000) that scientific literacy is one of the foremost goals of science education. Nation vision and expectation is that everyone to become scientifically literate citizens. Considering this view, educationist, policy makers and stakeholders realised that schools have prime responsibilities to prepare the children with scientifically literate citizen. It was recommended by Secondary Education Commission (1952) that the common need of middle school students in the area of science can be met best by formulating “general courses”. At the High school stage, there will be a specialised reorientation of the science courses and Physics, Chemistry and Biology will be taught as independent subjects.

The outcome of science teaching in schools should be make the students to understand the basic scientific concepts, facts and principles, process skills/methods, to develop scientific attitude, and apply the basic scientific concepts and skills in their daily life. UNESCO (1992) formally expressed the objectives for learning science as concepts, process skills and attitudes. Till

1960s, science teaching in schools was dominated by facts, principles, laws, theories and concepts. Much importance was given to products of science rather than process of science. After realising the importance of process of science, it was included in the school science curriculum. NCERT identified the process approach as one of the core elements of the science while planning the integrated curriculum for middle schools students. It emphasised that science curriculum must stress more on the processes than the products. UNESCO (1978) stated that understanding of processes of science as one of the most important objectives of the integrated science programme followed in the middle classes (Sixth to Eighth) of the Indian schools. According to Brown (1968) a study of the list of science teaching objectives in India reveals that the widespread concern of science educators with student development of an adequate understanding of the processes of science if reflected in all the science education programmes. By considering the importance of process aspects of science, almost all national level documents (Kothari Commission, 1964-66; NPE, 1986; NCF, 2000, 2005) recommended that process skills in science is an integral part of science education, and developing process skill is one of the objectives of science teaching.

1.1.1 Definitions of Science

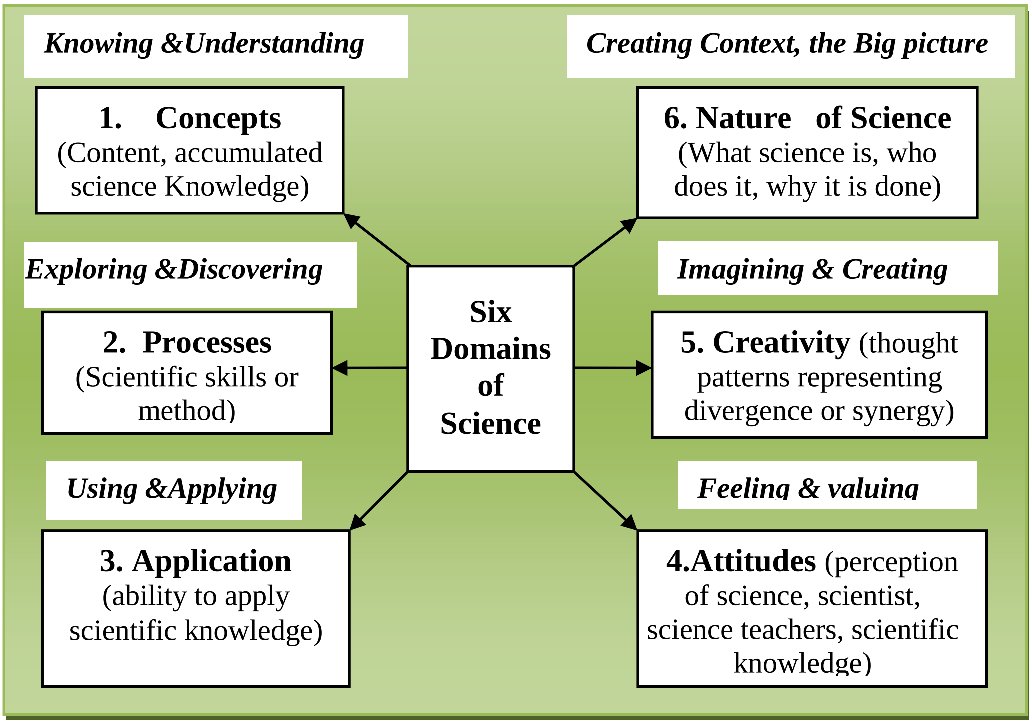
Science is a term that encompasses many field or disciplines. The nature, structure and functions of science have been differently described by various scientists and philosophers. It is not easy to give precise definition on what is science. However many scientist, researchers, and philosophers made attempts to define science. According to Frederick Fitzpatrick (1959) "Science is a cumulative and endless series empirical observations which results in the formation of concepts and theories, which both concepts and theories being subject to modification in the light of further empirical observations. Science is both body of knowledge and the process of acquiring knowledge. According to the Columbia encyclopaedia "Science is an accumulated and systematised learning in general usage restricted to natural phenomenon. The progress of science is marked not only an accumulation of fact but by the emergence of scientific method and of scientific attitude". By analysing the different definitions of science, following inferences are derived

- Science is a systematic way of acquiring knowledge. It is dynamic, tentative and no absolute knowledge.
- Science is a process as well as product. The process of science is a set of skills followed by scientist or students while discovering or verifying theories. Products of science includes facts, theory, law, principle and generalisation etc are the outcome of process.
- Science is an endless process of search of truth. Human mind is always busy in pursuit of exploring the unknown.
- The process of science is given more preference than the product of science.

1.1.2 Domains of Science

Science curriculum in school covers following domains such as cognitive affective and psychomotor. All the three domains develop students' higher order thinking skills. Teachers should not focus only on cognitive domain; it is important that teaching of science should develop other domains of science such as affective and psychomotor. All the domains of science should not be learned in a fragmented manner, it should be learned through integrated way. The method of teaching science and science learning should develop knowledge and skills, and attitudes which comes under the different domains of science. Enger and Yager (2001) stated that learning science promotes scientific literacy and it organised around six domains **(i) The Concept Domain:** it includes facts, laws or principles, theories, and the internalised knowledge held by students fall under the umbrella of the concept domain (Yager and McCormack, 1989). **(ii) The Process Domain:** it includes the 13 processes identified by the AAAS (1968) in the development of science: A Process Approach is generally accepted sets of processes that scientist use as they accomplish their work. **(iii) Application Domain:** it is the extent to which students can transfer and effectively apply what they have seemingly learned into a new situation, especially one in their own daily lives (Gronlund, 1988). It is important because students use concepts and processes **(iv) Attitude Domain:** It includes development of positive attitude towards oneself and development of more positive attitude towards science in general. Gardner (1975) explained two distinguishable general categories of attitudes (i) attitude towards science (i.e., interest in science, attitude towards scientist, and attitudes towards responsibility in science) and (ii) Scientific attitude (i.e., open mindedness, honesty, or scepticism). **(v) Creativity Domain:** Creativity is integral to science and scientific process. Creativity promotes divergent thinking, alternative viewpoints, novelty, solving problems and puzzles. Creativity plays an important role in many of the processes of science and in doing science **(vi) Nature of Science Domain:** The nature of science is about how the ideas are generated and how these ideas are developed through particular ways of observation, experimentation, and inferences. The nature of science also talks about the way of knowing science. The outline of six domains of science shown in the Figure_1.1.

Figure_1.1: Domains of Science



1.1.3 Nature of Science (NoS)

Science is always search of truth, scientific concepts are uncertain and it is subjected to modify the existing laws, theories, and generalisation. Scientific knowledge, skills, attitudes are important for all citizens and it comes under the Nature of science (NoS). National Science Teachers Association (NSTA, 1982) stated that understanding the nature of science is one of the prime responsible for scientific literate person. Process and products are one of the important aspects of NoS. Process leads to the development of products, and the products can be verified through process. Science teaching needs to address the processes and products of science but too often that present science teaching in schools teach science as a subject with very little/no connection to the real world therefore students fail to connect between what they learnt in science class and how to apply in natural world. Lederman (1999) stated that teaching NoS science can increase student interest in science and can enhance their content knowledge and increase the student achievement. It is quite abstract to define NoS. However it mainly stress the way of knowing science, methods/process of science, and epistemology of science. By observing of meaning of NoS stated by various researchers the following tenets have been identified, they are

- Scientific knowledge is tentative and it is subjected to change if new information is acquired.
- All Scientific knowledge is partly based on empirical evidence. Empirical evidence which is any evidence is measurable or observable. Any other way of knowing things that lacks empirical evidence is not connected as scientific knowledge.
- Scientific knowledge is created by scientists based on observation and inference.
- Dual nature of science is product and product.
- NoS develop one's attitude towards science and science learning.
- Imagination and creative thinking are the integral part of science.
- Scientific knowledge is socially culturally embedded.
- NoS include sociology philosophy and epistemology of science.

1.2 Science in Post Independence India

In the beginning of twentieth century science was not a school subject. Science existed only in the universities. India Science Congress also did not help in noticeable contribution towards teaching of science in schools in the early part of twentieth century (Das, 2005). After independence the development of science education greatly accelerated by recommendation of Commission, Committees, Policies. By looking at the scenario of science education, University Education Commission (1948) remarked that "our Secondary Education remains the weakest link in our educational machinery, it needs urgent reforms". Similarly, Secondary Education Commission (1952) made following recommendations:

- It is desirable to formulate "general Science" courses for the middle stage.

- Teaching of general science as a compulsory subject in the secondary and higher secondary schools.
- There is a need of different approaches.
- Need of curriculum reformation with logical and scientific demands of the subjects than the needs.
- Memorisation should be de-emphasis.

In 1956, All India seminar on the teaching of science in Secondary Schools was the first effort concerning to school science education in terms of teaching, equipments, examination, study materials etc. It suggested that uniform systems of Science teaching for the entire country situated to its needs and resources. Tara Devi report (1956) advised that teaching of science should develop the abilities to solve problems, and inspire towards scientist and new inventions. In 1957, National Science Policy Resolution (NSPR) focused to encourage and initiate with all possible speed to fulfil the country needs of science education. Kothari Commission (1964-66) advocated that science is an important element in the school curriculum, further recommended that science should be taught on a compulsory basis to all pupils as a part of general education during the first ten years of schooling and recommendation were implemented in 1975 when Science for All (SFA) was introduced as a part of general education during the first ten years of schooling with this 10+2+3 education schemes started with an additional year of schooling in the country. In 1977 Ishwarbhai Patel Committee submitted its report on curriculum for ten year school. NPE (1986) recommended to accelerate the national growth and Science Education should be given high priority. The Programme of Action (PoA, 1992) recommended innovative ideas like open book examinations, diagnostic evaluation, and training and orientation for teachers. In 1996, Public Report on Basic Education (PROBE, 1996) conducted a survey in rural areas of northern state. The findings of the report brought out some suggestive measures to improve classroom environments, utilisation and maintenance of resources, pupil teacher ratio.

Science Education was flourished by National and International bodies such as UNESCO, UNICEF and NCERT, and has taken laudable efforts to improve the Science Education at School level by providing training to science teachers, supplying science kits, materials etc. Apart from that there are some macro level programmes and interventions for example, DPEP which has since been extended into SSA and it is being sustained over several years, now upgraded into RMSA. Under this programme science kits, equipments, modules were supplied, and training programme for teachers were provided. Micro level interventions programmes like Homi Bhabha Centre for Science Education (HBCSE) of the Tata Institute of Fundamental Research popularised the science and talent searching programme, also the centre developed and supplied study materials. Hoshagabad Science Teaching Programme another example of micro level intervention for developing Science Education by preparing materials, kits, training modules, textbooks. Other small scale programme like "Prashika" "Lok Jumbish Parishad" also involved in fostering Science education in terms of pedagogy, learning materials, and science awareness. Some of the states established centres for science. For example, State like Gujarat established Community Science Centre in each district to develop scientific temper and to create awareness about science among students and society.

Technology cannot be isolated from science. The basic principle behind the products of technology is "science". Science leads to invent technology, through technology scientific knowledge can be further expanded. Considering the need and worth of Science and Technology (S&T) in the school education, NCF (2000) suggested that "learning of science in general education up to secondary stage needs to be replaced by learning of science and technology in view of the strong organic linkage between the two. In 2004, NCAER first time brought out a report called "India Science Report". It shows the students and parents' interest towards learning science. Subsequently, NCF position paper on Science teaching (2006) recommended constructive method of science teaching. Based on the recommendation, NCERT department of science and mathematics revised the syllabi in 2006 and developed new textbook during 2006-08 curricular material related with laboratory manuals are being used by the teachers and students.

The above observations reveals that laudable effort and initiation taken by national level and district level programmes, results considerable progress observed in science education for example, Nation incorporated science as a compulsory subject upto X standards in all schools; students' shows interest towards science (India Science Report, 2004). On the other side, by and large many problems persist in general, particularly in teaching learning. It was stated by NCF (2005) that most students' quality unacceptably poor, for majority of the students science is just another demanding and difficult subject to be learnt by rote, and small minority of students come out of the system with outstanding competence in science comparable to international standards. In most of the schools, objectives of science teaching was not achieved, particularly laboratory facility, teachers' availability, overcrowded classroom, overloaded curriculum, lecture method of teaching are serious concern in school education. It is therefore require several reforms to accomplish the objectives.

1.2.1 Objectives of Teaching Science at Upper Primary Level

The upper primary children getting first exposed to study science as a separate subject. This is the stage wherein students can construct basic scientific concepts, acquire skills, and develop attitudes. According to Piaget, upper primary stage students are in formal operation stage (age of 11 to 14). Children at this stage very much interested to operate science equipments and experience the process of science. It is therefore the objectives of teaching science should fulfil the needs and interest of learner. The objectives of science teaching stated by Commissions and committees including Secondary Education Commission (1952), Kothari Commission (1964-66), NCERT (1990), National Curriculum Framework (2000 and 2005) are as follows

- Teaching of science should lead to development of certain values, and it should link scientific principles with daily life experiences of the learners.
- Acquisition of skills for planning and executing socially useful productive work with a view of making education work based.
- Science teaching should be placed in the wider context of children's environment to equip them with requisite knowledge and skills to enter the world of work.
- Instead of loading the students with scientific information, efforts should be made to help them to learn key concepts which cut across all the discipline of science for developing curiosity and to create awareness and understanding.
- Science teaching should engage the learners in acquiring methods and processes that will nurture their curiosity and creativity particularly in relation to the environment.

- At this stage emphasizes should be given on acquisition of knowledge and many skills, ability to think logically, to draw conclusion and to make decisions at a higher level.
- Science teaching at this stage should initiate the student into the use and appreciation of the scientific method by which facts are discovered, relationship established, and sound conclusion reached.
- Teaching and learning of science needs to be characterised by emphasis on processes i.e. experimentation, taking observation, collection of data, classification, making hypothesis, and drawing inferences.
- Acquisition of knowledge through observation study and experimentation in the area of social and natural science.
- Exposing the children to the process of science, teaching of science should stress more on the processes than the product.
- Teaching of science should develop scientific attitude and scientific temper.
- Developing measurement and manipulative skills and to encourage the use of locally available resources.
- The emphasis on the process skills of science, and it continue through the upper primary stage to enable children learn how to learn themselves.
- Learning should be made active through experiential mode.

In a nut shell, from the above objectives it can be observed that more emphasis was paid to process of science. In contradiction to the above objectives, status of science teaching in schools revealed the dismal picture.

1.2.2 Status of Science Teaching in India

Looking at the contemporary scenario of science education in schools, the issues and challenges are more with regard to instructional method, laboratory and equipments facilities, curriculum materials, and evaluation system. Of the above issues and challenges, instructional method plays a significant role in science education at any stage. Science teaching largely follows lecture method; occasionally demonstration was conducted in the classroom or laboratory. Science teaching was not emphasising the process aspects. Science teaching was dominated by facts, concepts, principles, and generalisation; teachers very rigidly following the experiments and investigations. It was recommended by Kothari Commission (1966) that there is a need of drastic change in teaching methods.

Successively, Secondary Schools Science Teaching Projects (1969) conducted by NCERT collaboration with UNESCO pointed out that science education is not seen sufficiently as a whole either from developing attitude, acquiring skills as well as gaining knowledge, and the topics studied and the methods employed are not sufficiently related to children natural interest, traditional attitudes towards learning science found in Indian Schools, investigatory method are not encouraged, rote learning is all common too. Nation struggling to achieve universalisation of elementary education this is because one of the factors may be that low attract school for enrolment and drop out at the elementary stage due to lack of infrastructure facilities, untrained teachers in teaching (UNESCO, 1984). A survey report by Indian Journal of Public Administration (1986) stated that most of the schools basic facilities for teaching learning process far from satisfactory level. 70 % middle schools had no laboratory facilities, and 41.5% had no blackboards.

NPE (1986) also stated that the Present curriculum narrowly conceived, learning has become a rather mechanical process of acquiring skills and teaching has been largely a process of coaching for examinations and testing the memory, present syllabus emphasising more on memorisation and recall of information little or no progress was made in training the pupils in practical side of science. Research findings (Veerappa, Ganguli and Vashista, 1991) revealed that the position of science teaching which was characterized by the “Herbatian” plane, lecture, lecture cum demonstration method and essay type examination (Fifth Educational Survey, 1988-92). Report of the National Advisory Committee on learning without burden (1992-93) pointed out that transaction of information rather than experimentation, exploration or observation characterizes the teaching learning process in most classrooms. Teaching is too mechanical very little or no active involvement by students in the process of learning; students are trained to blindly memorise the content without thorough understanding of concepts. A survey conducted by PROBE on elementary education in the year 1996, findings reported that the following facilities such as blackboard, playground, drinking water, library, teaching kit are unavailable or available but not functional, similarly poor enrolment, inadequate teachers, lecture dominated teaching and rote learning, many of the classroom are not conducive for learning.

Malhotra (1998) and Umasree (1999) study findings reveal that teachers often provide lecture and students are rarely given opportunity to do things or take initiatives largely, and students observe the teacher rather than actively participating in the classroom. Thirty years Hoshangabad Science Teaching Programme (1972 -2002) stated that "the dismal picture of science teaching is nothing new; it is mainly emphasis of textbook based rote learning, no scope for experimentation, exploration". Teachers are not only transmitter of knowledge of science but also to engender in students a passion for science. Teachers of science have the challenging task of involving the students in scientific enterprises through science teaching. India Science Report (2004) pointed that Student's science learning is low, because inadequate time to complete syllabus, lack of scientific equipment, inadequate physical infrastructure and lack of good teachers. Interest in science as well as satisfaction with the quality of science teaching declined as the age increased, all these issues may fail to express excitement towards science education. Aravind kumar the Director of Homi Bhabha Centre for Science Education stated that "it is unfortunate that the majority of the school across the country teach science in a boring and mechanical style allowing little room for original thinking and investigation. Most of the time, students spent on searching for correct answer; this is false interpretation of science teaching. Science is all about doing and learning even through mistakes (HBCSE, 2004).

The above observations are the evidence for poor transactional method employed by science teachers in most of the schools. Science is only subject having more scope to do experiment, investigation, demonstration, activity and discovery and so on but it is unfortunate that there is no innovation in teaching and assessment. Teachers are not providing opportunity for the students to do hands on-minds on experiences. Most of the time Teaching was going on in classroom; development of scientific skills, interests, attitudes, creative thinking, problem solving skills are remaining in an utter state of neglect. Constructivist approach of learning science emphasis that learners are prime concern in learning process, learners have self autonomy to learn knowledge and skills, active involvement by the student are the major focus; teacher not to dictate the information and learners are constructor of knowledge and skills (NCF, 2000 and NCF 2005). Looking at the dull picture of science teaching, policies and commissions made recommendation to improve the method of teaching since 1966 but the status of science teaching was unsatisfactory. PROBE revisited in the year of 2006 in the same northern states, the survey reports that there has been major progress in the PROBE states in schooling facilities and enrolment rates. At the same time, fundamental problems remain prevails that the children who are enrolled are not necessarily in school, and mere attendance does not guarantee learning, many children who attend school are in classes where there little teaching activity. Teaching activity, where it does not exist, often translates to mindless rote learning, quality remains a serious concern, with low levels of teaching activity observed. Schooling situation in India remains dismal in international perspective. Enormous challenges that lie ahead in the area of upper primary schooling. Physical infrastructure is far from sufficient, numbers of teachers are not adequate, low levels of teaching activity observed in the 2006 survey. Indian Institute of science Bangalore, and NKC (2008) stated that teaching science through experiments is largely missing in most schools. Even where the laboratory is available, they are not upgraded. The students suffer due to lack of science material; laboratory equipments deteriorate due to lack of maintenance, overcrowded classroom, and chalk and talk method of teaching.

It is necessary to strengthen the quality of science teaching, rote memorisation should be de-emphasised. There should be active involvement from student side, innovation and creativity to be promoted. Need a paradigm shift from “listening science” to “doing science”. 96th Indian science congress also suggested that teaching of science needs to be refined substantially it must help the students to develop skills of procuring information and its analytical examination. Opportunity should be given for the students to carry out experimentation and investigation. Process skills should be nurtured in students. National Curriculum Framework (2000, 2005) advocated that teaching and learning of science needs to be characterised by focussed emphasis on processes of science. There is a need of alternative textbook which includes activities and experimentation for observation because scientific concepts are to be arrived at mainly from activities and experiments. National Knowledge Commission (2006-09) recommended that all school children should be encouraged to involve in some practical activities that require working with hands. Teachers of science should not strictly follow only textbook and train the students to memorise the concepts by ignoring the process skills. Content transmission is not the goal of science teaching. Basic content of science is important but those contents should be learned through process of science. Process aspect of science is more important than the product. Process skills are fundamental for formulating scientific concepts; rediscover the new knowledge, to develop scientific attitudes, to promote logical and creative thinking, and curiosity.

1.3 Product and Process of Science

1.3.1 Product of Science

It is stated in the NoS that the dual nature of science is process and product. Products are the outcome of process. Systematic observations and experimentation leads to the formulation of theories and generalisations. Empiricism generally encompasses systematic study of facts, theories and generalisation. Enger and Yager (2001) opined that central focus of science instruction is to understand the concepts. Concepts are always tentative; all propositions are subject to being revised or falsifiable. Hurd (1971) opined that significance of concepts and facts are constantly shifting within the scientific discipline and new ideas and theories leads to change present knowledge.

NCF (2005) suggested content validity is one of the basic criteria for science curriculum and it demands that science curriculum must convey significant and scientifically correct content. The content presented in the curriculum is not just for memorisation, it is for comprehension. Students should not come out of science class with a memorised set of definitions without understanding the contents. Students must know the reason behind the concepts for example why warm air rises up, what is essential to support combustion, how sound travels in a medium. Practical learning should be promoted and rote learning should be discouraged. Such learning becomes more permanent, meaningful and concrete. The purpose of learning science at early stage is not behave like scientist, rather the purpose is to develop process skills, concepts and attitudes towards science which will enable them to cope up effectively for their further education. The science process skills such as observation, classification, communication, measurement, prediction and inference and so on can be translated into immediate behaviour by the child as he attempts to understand the phenomena of science encountered in his environment. Pritam Singh (1971) says that pupil should observe, measure, classify, use numbers, see relationship, make hypothesis, devise experiments, interpret evidence, draw conclusions and verify the findings. It refers that, systematic way of knowing science.

1.3.2 Process of Science

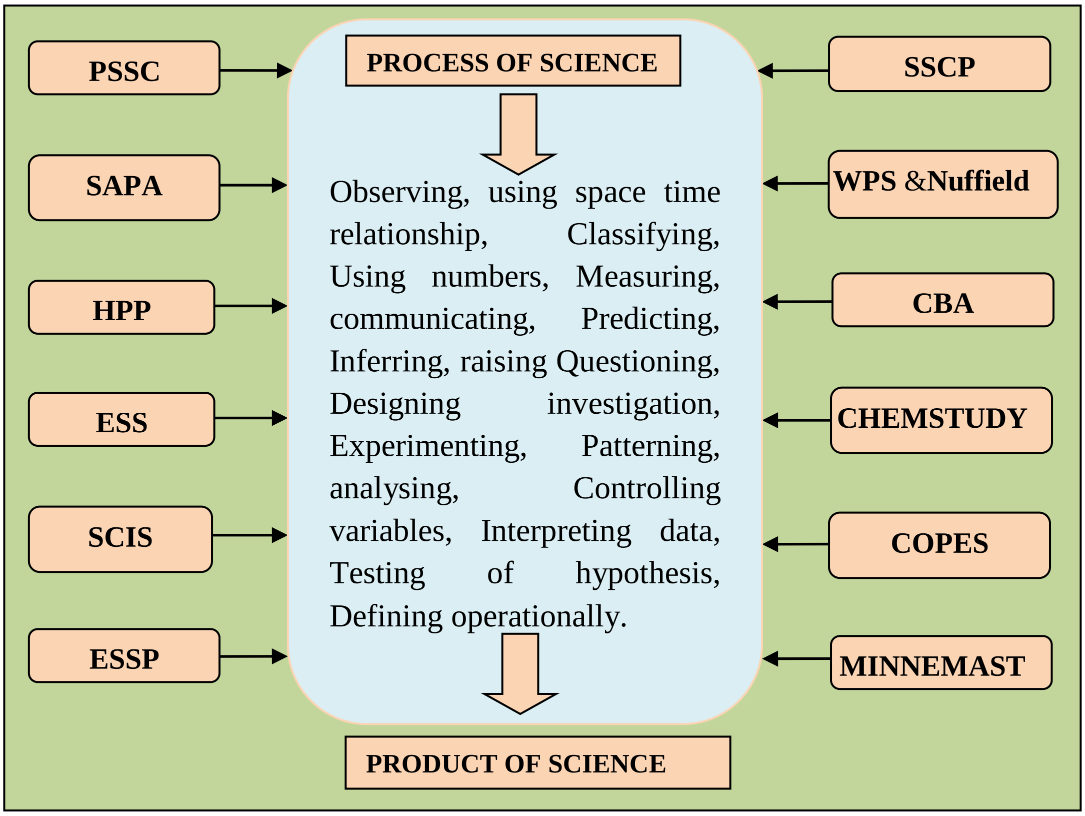
Science is both thought and action. Thought is nothing but the ideas, conception, and beliefs about the natural phenomenon wherein the action is methods and procedures or processes followed by scientist or students. The process includes certain set of skills and abilities such as observation, measurement, communication, testing hypothesis, design experiment, changing variable etc. These skills are commonly called scientific method. These skills are the foundation for formulation of theories, generalisation, principle, and laws. It encourages the spirit of inquiry through laboratory experiments. Menon (1986) stated that the processes of scientific inquiry represent the spirit of science as an activity and its essence that it distinguishes science from other discipline. Hands-on minds-on experiments and activities provide rich learning experiences for the students to acquire science process skills. These are chiefly mental skills, but also associated with physical skills.

1.4 Concept and Genesis of Science Process Skills

Science process skills are commonly used the term now, but one point of time synonymously it was termed as scientific method, scientific thinking, and critical thinking and processes of science. Harlen (1992) stated that process skills include planning, following directions, observing, experimenting, measuring, predicting and inferring; these are concerned with processing evidence and ideas, and so are often called process skills. Science process skills are the set of procedures which are employed by scientist during investigation and discoveries. SAPA (Science: A Process Approach) describes that scientific process skills are defined as transferable skills that are applicable to many sciences that reflect the behaviour of scientists. By observing the above definitions it can be inferred that science process skills are the set of intellectual skills which are performed by our mind in association with sensory organs during the process of science.

Early to 1960 there was a proliferation of new science programmes. This was a manifestation of a shift in emphasis of teaching from content to process skills. The process of science first implied by the American Association for the Advancement of Science in their programme (AAAS) called Science: A Process Approach (SAPA), after 1960 “Content” was de-emphasised (Bhatt, 1988). Following curriculum change projects were launched and renovated to emphasis processes of science in science teaching namely Physical Science Study Curriculum (PSSC), Science A Process Approach (SAPA), Harvard Physics Project (HPP), Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS), Elementary School Science Curriculum Improvement Study (ESSP), School Science Curriculum Project (SSCP), Minnesota Mathematics and Science Teaching Project (MINNEMAST), Conceptually Oriented Programme in Elementary Science (COPES), Chemical Education Material Study (CHEMSTUDY), Chemical Bond Approach (CBA), Science in Process, Warwick Process Science (WPS), Nuffield courses in the UK (Figure_1.2). These curriculum reforms and projects stresses on process skills through different approaches such as inquiry approach, investigatory approach, and discovery approach of teaching science. All the Curriculum reforms and projects findings reveals that the process approach is more effective in increasing pupils' science achievement and attitude compared to traditional science program (Blosser & Mayer, 1982). By realising the need and importance of science process skills, Current Science Education Standards such as Science for All Americans (SAA, 1990), the Benchmarks for Scientific Literacy (1993), National Research Council (NRC, 1996), and National Science Teachers Association (NSTA, 2002) advocated the Science Process Skills among the school students. By considering the importance of process aspects of science, much earlier Secondary Education Commission (1952) recommended that science curriculum should provide opportunity to carry on practical activities and laboratory work. Subsequently, all commissions and policies continuously emphasises development of process skills. At present, there is a shift in the Science curriculum to emphasise from content of science to process of science. It was stated in the NCF (2005) that development of process skills upto standard X is one of the objectives of teaching of science.

Figure_1.2: Curriculum Projects



1.5 Classification of Science Process Skills

The American Association for the Advancement of Science (AAAS), UNESCO (1992) identified thirteen process skills under two major classification namely Basic and integrated. Basic Science Process Skills (BSPS) are Observing, Classifying, Communicating, Measuring, Predicting and Inferring. These basic process skills are foundation for acquiring the integrated process skills. Integrated Science Process Skills (ISPS) are identifying and defining variables, describing the relationship between variables, formulating and testing hypothesis, collection of data, designing investigation and experimentation, manipulating the variables, identifying the cause and effects, acquiring organising and displaying the data with charts, graphs, tables. All these process skills are interrelated; there is no sequence or particular order of these skills. Any skill can begins first, all other skills follows later. But most of the time observation skill starts first, rest of the skills follows later.

1.5.1 Basic Science Process Skills (BSPS)

1.5.1.1 Observation

Observation is the fundamental science process skill among all other process skills. The process of observing is taking in information through sense perceptions. It is the most basic and broadest skill through which all other skills are refine it. Good observations lead to the development of other science process skills such as communicating, predicting, measuring, classifying and inferring. Observation begins from every activity of science. It is more than just 'seeing' and it is associated with collecting data using all the senses such as eyes nose ears tongue and skin as well as instruments that extend beyond the reach of our senses. Seeing allows the students to notice such properties as sizes, shapes, colour of objects or organisms, it is also to gather fine details. Hearing makes knowable properties of sounds such as loudness pitch and rhythm. Touching is to know the texture hardness roughness softness powdered crystalline in nature hotness and coldness. Tasting is to feel how some properties of substances are bitter sweet sour and salty. Smelling is to recognise the odour of particular chemical substances, and food items based on the commonalities and differences.

There are two aspects in development of the observation skill: attention to detail and ability to distinguish what is relevant to a particular investigation. UNESCO (1992) said that what children say, draw or write about what they see smell hear or taste or feel with their fingers is an important source of evidence of their observation. During observation one can use hand lens and microscope for observing the minute detail about the particular events or occurrences. Observation should be till the end of event or completion of experiments not just only in the beginning. Deep observation can provide more accurate information.

The observation can be classified both qualitative and quantitative. Qualitative observations are qualitative in nature that is descriptive terms such as colour, smell, texture, properties and characteristics' of object or things or organisms. Quantitative observation refers to notice the numbers in terms of object or things or organisms. Quantitative observations usually are more precise than qualitative observations. For example: observing the number of legs in centipede millipede or number of segments in earthworm or number of tentacles or antenna in some insects or if a student reports that a lemon has six seeds it is likely that other children observing the same piece of fruit would make the same quantitative observations. Observations using comparisons such as "an arm's length" or "as big as my fist" are considered quantitative.

1.5.1.2 Classification

Classification is the process of sorting, grouping, ordering or arranging objects on the basis of similarities and differences, larger or smaller and other common characteristics. Most intuitive thinkers can select and group the objects by some common property such as colour shape and size. The classification can be qualitative as well as quantitative. Qualitative classification based on size shape colour habit and habitat and the nature of substances such as smoothness roughness hardness softness opaqueness transparent solids liquids gases etc. Quantitative classification is based on number for example: age, number of leaf or petals in a flower. The classification can be binary or multistage. In binary classification system a set of objects or things are classified into two subsets for example (i) living being is classified into plants and animals (ii) animals are classified into vertebrates and invertebrates. Binary classification is the most basic form of classification. In multi-stage classification each subsets follows consecutive binary classification or succession of binary classification for example, subset animals further classified into mammals birds lizards reptiles and so on. Classifications of things or objects or substances are not only unidirectional, it can be multidirectional also i.e. grouping or arranging them into more than one category based on presence and absence of certain attributes. For example: a group of living organisms are classified into birds reptiles insects unicellular multicellular herbivores carnivores omnivores terrestrial and aquatic animals vertebrates and invertebrates mammals etc.

Objects, things, substances and organisms can be classified in different ways but before going for classification one has to think whether the particular property is being present or not. Thorough observation is needed before arranging or ordering the things. Classification skill helps to understand and conceptualise the scientific ideas in a systematic manner. Classification helps the students' to retrieve information from a conceptual scheme. Classification skills develop creativity and also develop divergent thinking. Classification skill helps to relate the objects having similar attributes through which concepts can be constructed.

1.5.1.3 Communication

Communication skill refers to convey of information from one person to another by verbal or nonverbal means. Verbal communication conveys the information orally using scientific terminologies clearly. Nonverbal forms of communication are through charts, graphs, maps, and drawings, symbols, pie chart, tables, chemical formulas of particular element or compound, symbols of electric component, flow chart. Harlen (1992) argues that both written and oral recording communication are integral parts of the activity because making records helpful for further discussion and display through adequate communication way for easy understanding. Making record is the part of communication which helps for future verification. It was stated by AAAS (1965) that Observation and communication are two process skills which are absolutely essential for an individual to relate to the physical world. Scientists use to communicate with another person about what they observed or discovered. They makes model, draw able graph or histogram symbols to convey the information. NCS (2002) stated that communication skill helps the learners to reflect on their own learning and to build confidence as a person.

1.5.1.4 Measurement

Measurement is the act of using numbers to describe objects or events. Measurement is a process wherein measure the attributes that are measurable such as temperature, length, breadth, height, area, mass, and volume. Measurement is a process which involves comparison of an entity with standard measurement. Measurement skill follows calculation, after completion of every measurement it should be written with proper measurement unit for example: Units like centimetre or millimetre Kilogram length breadth temperature weight mass area volume etc. Prior to measure the objects or liquids one has to choose appropriate measuring instruments such scale, ruler, meter stick, yardstick, balance, clock, thermometer, graduated cylinder or containers, protractor, screw gauge, vernier calliper, and tape. Also it is very essential to ensure that the selected measurement device is standardised or not, capacity (range), increment values, and calibration or adjustment to ensure the proper use of the instrument, whether the device is numbered or unnumbered, and ensure the accuracy of instrument.

1.5.1.5 Prediction

Predictions are the statements about what might happen or could be expected to happen in the future. It is based on some relevant prior knowledge in a form which can be investigated. Prediction is the act of predicting the forecasting events based on a previously developed model or experience. A model is a visual or cognitive representation that relates various aspects to one another, a well developed model allows one to be more confident in making predictions related to a situation, for example: meteorological model that allows forecasters to make accurate predictions of future weather conditions in a locale (Bentley, 2007). Prediction can be based on the use of available evidence or past experiences but there should be proper justification for the prediction (UNESCO, 1992). For example, based on observation of simple pendulum experiment one can predict what would happen if length of the pendulum increased? Predictions, unlike inferences, are verifiable. A prediction is not a wild guess; a guess has no rational foundation. Predictions are kinds of thinking that require learners' best guesses based on the information available to them. It involves the learners in using knowledge to decide what will happen if something is changed in a situation. Prediction can develop one's deep thinking and logical analysis and interpretation. Before conducting an experiment or activity one can predict 'what will happen? Later, prediction should be verified. Prediction also can be based on inferences.

1.5.1.6 Inference

Inference is the act of making statements based on observations. Inference is a process of making suggestions, conclusions, assumptions or explanations about a specific event based on observation. Inference is different from observations, there can be a misconception that observations are inference but both are different conceptions. Observation is the use of one's senses to perceive objects and events and their properties. Inferences are making statements or conclusions after a deep observation and understanding of a phenomenon, therefore observations are the base for any inference. For example a student observing a plant and reported that "two leaves are dying". In this, student made inference based on the observations of colour difference of the leaves (two leaves colour is yellow or brown and other leaves are green). Sometimes more than one inference can be made based on a list of observations. Inference skill encourages metacognition process and it stimulates higher order thinking skills, problem solving skills and decision making skills. Inference helps to identify the Cause and effect relationship.

1.5.2 Integrated Science Process Skills (ISPS)

Formulation of Hypothesis: Formulating the tentative statements or expected outcome for experiments. These statements must be testable.

Identification of Variables: Stating the factors or variables which affect the experiment. It is important to manipulate the variables being tested and keep all other variable constant. The one being manipulated is the independent variable. The one being measured is the dependent variable.

Defining Variable Operationally: Operationally describe the variables of an experiment.

Describing Relationship between Variable: Describe the relationship between variables in an experiment such as independent and dependent variables.

Designing Investigation: Design an experiment in a systematic way to test a hypothesis.

Experimenting: Carry out an experiment carefully by following correct procedure so that results can be verified by repeating the procedure several times.

Collection of data: Collect qualitative and quantitative data during experiments through observations, measurements and any other means. Employ sensory organs to collect information.

Recording the Data: record the quantitative and qualitative data for further use.

Analysing Investigations: Interpreting data statistically, identifying human mistakes and experimental error, evaluating the hypothesis, deriving inferences, and design further investigation if necessary.

Identifying the Cause and Effect Relationship: Identify the factor or variable which affect the experiment.

During the process of doing science, scientist and students employ both basic and integrated science process skills. By employing the process skills one can acquire the procedural of doing science and conceptual clarity.

1.6 Nature of Science Process Skills

Process skill domain has its own values and identity in science. It is the most important domain wherein all other domains of science can be developed. Process skills are inventive and exciting activity to search the knowledge. These skills must be nurtured among the students in a systematic manner so that they become scientifically literate in their life. The nature of science process skills describes the systematic method of knowing science. The nature of science process skills have certain characteristics, they are

- It leads to the development of scientific concepts.

- Agreement and disagreements are the important features of process skills through which inference can be derived.
- Productive thinking can be encouraged in relation to the processes of science.
- Process skills follows empiricism many empiricists or scientist such as Fleming, Einstein, Newton, Galileo, and early Greek scientist Aristotle and Archimedes are used these skills during their inventions.
- Verification and generation of new concepts is one of the important natures of process skills.
- During Process skill sensory organs associated with cognitive operation therefore it sharpens the thinking skills and these thinking skills are developmental in nature.
- Process skills develop scientific attitude, scientific temper and values.
- It helps to find out the relationship between cause and effect about a particular phenomenon.
- Intellectual abilities such as curiosity, creativity, problems solving, decision making are intertwined with nature of Process skills.
- Process skills connect with the persons to the physical and biological world.
- Process skills helps the learner to learn any complex concepts in science, also it facilitate the learner to learn other subjects.
- Accuracy and truthfulness.
- Abilities to formulate new ideas, concepts by their own.
- It removes misconception in science and it freedom from superstitious believe.

1.7 Purpose of Developing Science Process Skills at Upper Primary Students

According to Jean Piaget theory of cognitive development, science instruction at upper primary stage plays pivotal role in developing process skills. At this stage, children can think and able to reason out with symbols, ideas, abstractions and generalisations. They are in a position to proficient in basic science process skills. NCF position paper on Science teaching (2006) suggested that process skills of science should continue throughout upper primary stage to enable children learn how to learn for themselves so that they carry on learning to even beyond school.

Several projects such as SAPA, ESS, SSCP, SCIS, MINNEMAST, and ESSP were conducted at elementary level students to enhance the process skills. Vaidya (2003) opined that unconsciously upper primary children use simple process skills during their exploration of the world but often teachers are not providing opportunity to refine or enhance the basic skills because of conventional instructional strategy followed in the classroom, results students unable to perform complex skills in their later education. Upper primary stage is a crucial for acquiring basic concepts and skills, the students who are proficient in process skills can become scientifically literate and they can improve the standards of their lives by using these skills. Initially children's process skills are limited and unsystematic; teachers of science need to give adequate inputs about process skills at very early stage so that when they grow, pupils use these skills proficiently. If process skills are not developed among the students of upper primary stage, then the teacher cannot expect them to develop higher order skills in their later stage. It is therefore, this is the crucial stage for developing science process skills.

1.8 Approaches and Methods for Developing Science Process Skills

Learning science is different from learning other subjects; science can be best learned through various learning experiences such as demonstration, field trips, investigation, discovery and experimentation etc. Teaching of science is not just delivering of scientific knowledge and expecting the students to memorise. Harlen (1992) stated that teacher should have the different view of learning, where the learner is active in understanding and using process skills to test and modify ideas rather than describing for rote learning. Effective teaching is always pupil centred so that students learn easily and effectively. According to Doraiswami (1970) the purpose of the syllabus is to make the child participate actively in the learning experiences in the classroom, there should be a greater emphasis on the 'processes of science rather than Products of Science. Process of Science cannot learn effectively through "Chalk and Talk Method". There should be an active involvement by the learner; teachers must engage the learner in "doing science" and "experience the science" such learning become concrete, meaningful and experiential.

There are different methods of learning such as active learning, activity based learning, cooperative learning, discovery learning and so on. Whatever may be the methods but method of learning should provide opportunity to the learners to receive hands-on and minds-on experiences. That can facilitate the learner to develop the concept and skills. The principle of constructivism is learners' experiences. Piaget (1977) opined that as a learner strives to organise personal experiences in terms of pre-existing mental schemes, knowledge is constructed. He further stated that the meaningful learning takes place within the children if the learning environment is appropriate and experiential. Experiential learning is one such a learner centred method that facilitates the learners' individuality. Experiential learning engages the students in the learning process individually and in groups because process and learners direct purposeful experiences are the main core of experiential learning. Harlen (1992) recommend that the experience provided will enable pupils actively to seek evidence through their own senses to test their ideas. Children can best learn science when they exposed in "hands on meaningful and relevant activities". In experiential learning, teaching is less and learning will be more. It stresses more on process approach. By considering the educational value of experiential learning it was recommended by national and state level educational policies such as NCF (2005), National Curriculum Framework for Teacher Education (2009), Gujarat State Board Curriculum for Science (2006), Tamilnadu State Board curriculum for Science (2009) and Common School Curriculum Bihar (2007) that the learning should be experiential. John Dewey stressed the concept of experiential learning much earlier, in the light of John Dewey philosophy, almost all the documents emphasising to incorporate experiential learning.

1.9 Historical Underpinnings of Experiential Learning

Learning is the key to personal development and experience is the key for meaningful learning. According to David Kolb (1984) experiential learning theorist; learning is the process whereby knowledge is created through transformation of experience. The simplest form of experiential learning (EL) means learning from experience or "learning by doing" (Croom, Lee, Talbert, and Vaughn, 2007 cited in Parker, 2011). The idea of experiential learning is not new in the field of education (Wulff- Risner& Steward, 1997). Learning through experience has been valued in all educational settings. Experiential learning in general has a long history rooted in the early work of John Dewey (1938). He is the one who attributed experiential learning movement in his educational philosophy (Hickcox, 1990), later there was a boom evolved in the 60's and 70's by the work of psychologist, sociologist, and educationist such as Piaget (1950), Kurt Lewin (1957), Paulo Freire (1970), Vygotsky (1978) and David Kolb (1984). The eminent Philosopher John Dewey written a book "Experience and Education" offering a justification for learning by doing. John Dewey in the mid 1930s used experiential education in multiple disciplines including sociology, anthropology, science and research due to its interdisciplinary nature (Carver, 1996 cited in Mughal and Zafar, 2011). Dewey work stressed the importance of students' engagement in real life experience in the development of a cognitive construct. In his view, the end goal of learning is not to get the right answers but rather to understand and use the experience (Warren, & Hunt, 1995). Kurt Lewin social psychologist who notably said "there is nothing so practical as a good theory". Piaget's theory of cognitive development describes how intelligence is shaped by experience. Piaget view on philosophy of learning is assimilation and accommodation; assimilation being the process of incorporating new experiences with prior knowledge already exists in mind, and accommodation is the process of prior knowledge being altered by new experience. According to Carl Rogers (1983) Humanistic Psychologist "experience is the highest authority, and the touchstone of validity is my own experience" Rogers distinguished two types of learning: cognitive (meaningless) and experiential (significant). The former corresponds to academic knowledge such as learning vocabulary or multiplication tables and the latter refers to applied knowledge such as learning about engines in order to repair a car. Paulo Freire (1970) stated that the goal of education is to raise the critical consciousness of learners by means of experiential encounters with the realities of their culture. Kolb (1984) believed that theory and practice should be integrated together. Modern theorist David Kolb works on experiential learning based on the educational philosophy of Dewey Kurt Lewin and Piaget, and he developed learning style inventory and experiential learning cycle. According to Kolb (1984) knowledge is results from the combination of grasping experience and transforming it.

Over the past fifty years, theorist and practitioners has made a significant contribution to our understanding and acceptance of experiential learning. From the foundation they have laid, new experiential approaches continued to evolve all over the world. In India, experiential learning is mushrooming in all educational system, the institute of experiential learning was established in Bangalore in the year 2011 by the experiential learning foundation trust and it supports education, research and developments (source: www. inexel.org), Indian Council for Agricultural Research also developing course structure, operational modalities and evaluation procedure for the experiential learning course which will be common to all discipline such as horticulture, forestry, dairy, technology, fisheries and home science (Source: www.icar.org.in/node). Most of the documents and reports on school education also recommended to incorporate experiential approaches in teaching learning process. Apart from these, there are 2453 research studies also conducted on experiential learning all over the world from school education to higher education covering all the discipline such as mathematics science agriculture tourism education psychology medicine nursing computer to develop knowledge and skills (Kolb and Kolb, 2008). Research Studies suggested that learning through experience is essential for individual and organizational effectiveness (Argyris and Schon, 1974; 1978). Experiential learning philosophy continues to gain recognition among the learner, teacher, and educator. This movement needs to be widened in all facets of educational systems to bridge the gap between the learner and the learning process, theory and the practice.

1.9.1 Experiential Learning and Experiential Education

Experiential learning should not be mistakenly used to interchange with experiential education. Various researchers understandably conceptualised the experiential learning and experiential education. Some of the definitions are as follows. Craig (1997) stated that Experiential learning is "knowledge, skills, and/or abilities attained through observation, simulation, and/or participation that provide depth and meaning to learning by engaging the mind and/or body through activity, reflection, and application". According to Colin and Beard (2007) Experiential learning as the sense making process of active engagement between the inner world of the person and the outer world of the environment. Whereas, Association for Experiential Education (AEE) defined experiential education as “a philosophy and methodology in which educators purposefully engage with learners in direct experience and focus reflection in order to increase knowledge, develop skills, and clarify values” (AEE, 2002).

1.9.2 Principles of Experiential Learning

In traditional classroom situation the instruction is highly rigid and authoritative, whereas in experiential learning students learn from one's own experience. The instruction is designed to engage the learners in direct hands on experiences for gaining knowledge and skills. Effective instructional methods have certain principles; accordingly Association for Experiential Education (2011) listed some of the experiential learning principles which are as follows

- Experiential learning occurs when carefully chosen experience are supported by reflection, critical analysis and synthesis.
- Experiences are structured to require the students to take initiatives, make decision and be accountable for results. Throughout the experiential learning process, the students is actively engaged in posing questions, investigating, experimenting being curious, solving problems, assuming responsibility, being creative and constructing meaning.
- Students are engaged in intellectually, emotionally, socially, soulfully and/ or physically. The involvement produces a perception that the learning task is authentic.
- The results of the learning are personal and form the basis for future experience and learning.
- Relationships are developed and nurtured: student to self, student to others and student to the world at large.
- The instructor and student may experience success, failure, adventure, risk-taking and uncertainty, because the outcomes of the experience cannot totally predicted.
- Opportunity is nurtured for students and instructor to explore and examine their own values.
- The instructor's primary roles include for setting suitable experiences, posing problems, setting boundaries, supporting students, insuring physical and emotional safety, and facilitating the learning process.
- The instructor recognises and encourages spontaneous opportunity for learning.
- Instructor strive to be aware of their biases, judgement and preconception, and how these influence the student.
- The design of the learning experience includes the possibility to learn from natural consequences, mistakes and successes.

1.9.3 Characteristics of Experiential Learning

While developing a learning activity it is good to understand what characteristics make the activity an experiential learning event. Burnard (1989) describes several underlining attributes that define an experiential learning activity (Beaudin, 1995).

- ❑ **Action:** the learner is not a passive receptacle but an active participant; and there is physical movement, not just sitting.
- ❑ **Reflection:** learning only occurs after the action is reflected upon.
- ❑ **Phenomenological**: objects or situations are described without assigning values, meanings or interpretations; the learner must ascribe meaning to what is going on; and the facilitator's meaning must not be automatically forced upon the student.
- ❑ **Subjective human experience**: a view of the world that is the learner's not the facilitator's.
- ❑ **Human experience as a source of learning**: "experiential learning then is an attempt to make use of human experience as part of the learning process".

According to Joplin (1981), experiential programs consist of several overarching characteristics:

- ❑ **Student-based rather than teacher-based**: the learning encounter starts with the students' ideas and concepts rather than the teacher's or the books.
- ❑ **Personal not impersonal nature**: personal experiences and personal growth are valued in the classroom.
- ❑ **Process and product orientation**: emphasis is placed as much on learning as it is on the "right" answer.
- ❑ **Holistic understanding and component analysis**: students are urged to fully understand the content through the analysis of primary sources of the material and/or experiences with the material.
- ❑ **Organized around experience**: the students' previous experiences are taken into account when creating the curriculum, as well as the new experiences that will be provided in the classroom, lab, or field trip.
- ❑ **Perception-based rather than theory-based: "**experiential learning emphasizes a student's ability to justify or explain a subject rather than recite an expert's testimony

- **Individual based rather than group based**: group identity and socialization skills are stressed; however, emphasis is placed on the individual learning within the group rather than on the group as a whole; criterion-referenced rather than norm-referenced.

1.9.4 Experiential Learning Environments

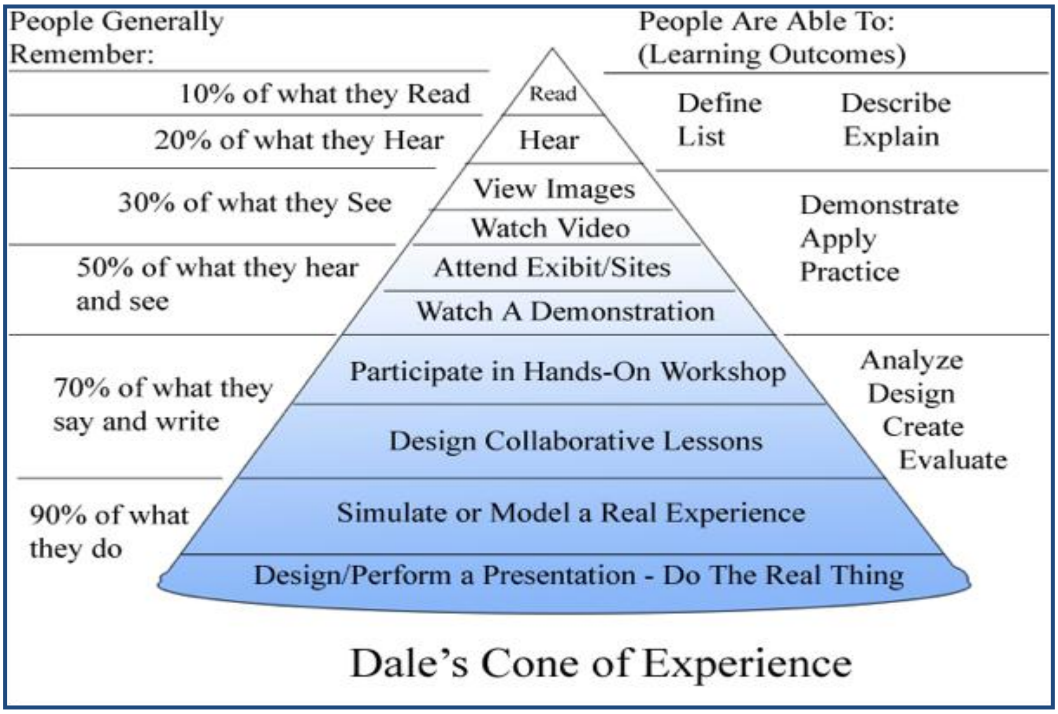
It is not easy to identify the place where the learning takes place effectively. Learning can occur anywhere, anytime, and by anybody but it is depends upon cognitive level, readiness of the learner and learning environments where he or she experience the learning process. Optimal learning can be influenced by the learning environments and learning experience. It was stated by Beard and Colin (2007) there are diverse range of places or spaces for experiencing the learning. It can be outdoor and indoor learning, real or virtual, natural or artificial learning, private or public, formal or informal those are used to facilitate the learning. Typically indoor learning environments have been strongly associated with lecture theatre, hall, classroom, multimedia theatre, and laboratory. Outdoor learning environment can be playground, zoo, museum, jungles, desert, mountains, gardens, parks etc. Artificial environment is a man made structure, device, or environment that stimulate a natural setting which can be used for teaching. Beard and Colin (2007) stated that the use of artificial spaces for experiential learning is of greater significance for knowledge creation.

1.9.5 Experiential Learning Activities

There are range of experiential activities and technique available for facilitators to help pupil to learn through experience. In experiential learning, fundamental activities and method is "experience" Educationist Beard and Colin (2007) listed some of the experiential learning activities such as projects, experiments, sensory simulation, problem solving, the use objects for variety of purposes, training kits, outdoor recreation, cartoon production, theatre, drama, art, storytelling and writing and reading, role play, simulations. Creating a variety of opportunity is the essence of experiential learning activities. Researchers used different experiential learning activities and techniques for developing knowledge and skills. Beasley (2010) used three experiential learning methods in secondary education such as experiments/lab activities; service learning projects, and field trips. Thomas (2012) selected the following experiential learning activities and methods such as role play, video clips, laboratory activities and storytelling to develop spiritual intelligence and emotional intelligence, findings revealed that the selected activities and methods significantly influence for the development of spiritual and emotional intelligence among the teacher educators. Taylor (2004); Horwath, (2004); Miller et al, (2005); Askeland (2003); Cummins (2006); Cummins Sevel and Pedrick (2006) also used diagrams, individual and network activities, reality play approach, multimedia learning environment, and use of reading and writing are the experiential activities (Wong, 2007). Sheetal (2010) used situational discussion, role lay, brain storming, group activities, group discussion under the experiential learning methods and techniques.

In 1969, Edgar Dale suggested various learning experiences in his cone of experience (Molenda, 2003). According to Edgar Dale cone of experience, learners retain more information and skills, and gain concrete learning experiences when they engaged in "doing" purposeful activities. Reading and listening are the least experience. The Edgar Dale (1969) cone of experience is shown in the Picture_1.1.

Picture_1.1: Edgar Dale's Cone of Experience

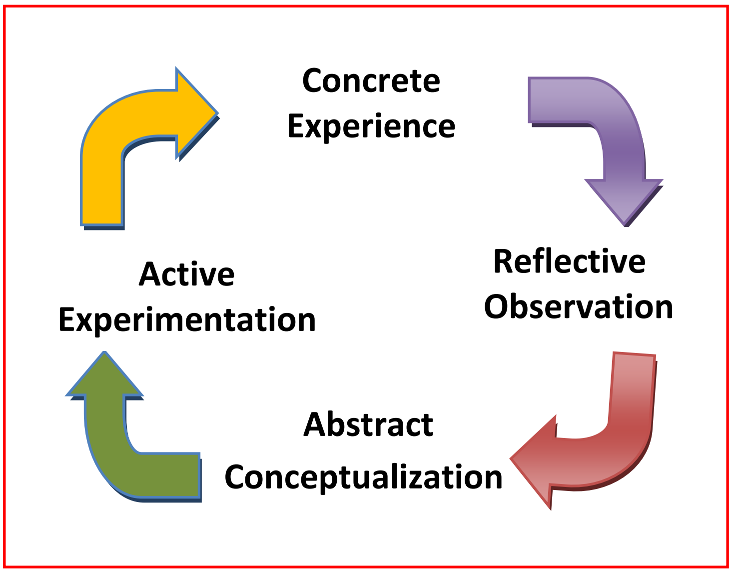


(Source: Beard and Colin, 2007, www.fsu.edu **Edgar dale 2002)**

1.9.6 Experiential Learning Theory (ELT)

Experiential learning Theory (ELT) was built upon the work of learning, and development theorists John Dewey, Kurt Lewin, Jean Piaget, Carl Jung, Paulo Freire, Carl Rogers (Kolb and Kolb, 2005). All of those believed that experience plays central role in learning and they laid foundation to evolve experiential learning theory. Dewey (1938) opined that “there is an intimate relation between the processes of actual experience and education”. It refers that learning must be based on real experience. Social Psychologist Kurt Lewin’s (1952) theory of action learning proposes that experiential learning occurs through a four stage cycle that involve engaging in two dimensions of naturally opposing activities: experience versus abstraction, and action versus reflection. Piaget's theory of cognitive development describes how intelligence is shaped by experience. Piaget (1970) suggested that individual can develop abilities by engaging activities according to sequential stages of cognitive development. He made a clear distinction between the two dimensions of learning: Experience and abstraction are the ways of assimilating new experiences into existing concepts, while action and reflection are the ways of accommodating existing concepts into new experiences (Kemp, 2007). Piaget’s last two stages are concrete and formal operations where knowledge is represented in symbolic terms. Symbols are capable of being manipulated internally with complete independence from the experiential reality (Kolb, 1984; Hickcox, 1990). Carl Rogers Stated that cognitive learning is meaningless and experiential learning is meaningful. He further opined that learning as a cycle that begins with experience, continues with reflection and later leads to action, which itself becomes a concrete experience for reflection (Rogers, 1996). Considering the ideas of theorist philosophers and Psychologist John Dewey, Piaget and Kurt Lewin and Carl Rogers, an American educational theorist David Kolb developed experiential learning theory or cycle (Figure_1.3). According to him experience as the source of learning (Kolb, 1984). He stated that ELT is the process whereby knowledge is created through transformation of experience. The theory provides a framework for understanding both cyclic nature of experiential leaning and individual learning tendencies (Yaganeh, 2006).

Figure_1.3: Kolb's Experiential Learning Cycle



The cornerstone of Kolb's model has four stages of learning. The first stage is Concrete Experience (CE): In this stage, students involve themselves fully openly without any bias. The second stage is Reflective Observation (RO): during this stage student reflects on and observes their experience from different perspectives. Third stage is Abstract Conceptualisation (AC): here the students create abstract concepts based on their observation. The final stage is Active Experimentation (AE): where the students apply or verify their theory through experimentation (Myers 2004; Yaganeh 2006). The descriptions of each stage of Kolb's experiential learning are as follows

Concrete Experience (feeling)

- Learners directly involve in the action process for understanding
- Learners feel the experience rather than listen teachers voice
- Learners use their previous experience
- Learners are self directed.

Reflective Observation (watching)

- Learners viewing the situations in multiple perspectives
- Learners apply their senses and gather informations
- Learners exercising the skills and observe the things reflectively, critically by action

Abstract Conceptualisation (thinking)

- Learners use their intellectual by thinking about the events
- Learners formulate theories from observations and experiences
- Learners develop explanations and hypothesis
- Learners make conclusion

Active Experimentation (Doing)

- Learners very actively experimenting with influencing or changing situations
- Learners have a practical approach and opposed to watching situations
- Learners verifying the concepts by their own

The four stages of experiential learning such as concrete experience, reflective observation, abstract concepts, and active experimentation constitute an experiential learning cycle or theory. These are interrelated in the holistic adaptive process of learning. ELT describes four developmental dimensions: affective, perceptual, symbolic and behavioural complexities (Hickcox, 1990). ELT exclusively provides the groundwork for learning that takes place in and out-of-classroom where learners advance by acting on their environment and experiencing the consequence of that action (Coleman, 1977).

1.10 Constructive Based Experiential Learning and Science Process Skills

Concepts and skills can be effectively constructed when the students engaged in science. Students interestingly perform experiments. Knowledge of science is hollow if concepts are not properly understood and skills are not acquired by the learner. Scientific knowledge should be self discovered by the students through process of science. There is a strong relationship between process skills and concepts. Process of science is not a part of science; rather science itself is a process. It cannot be learned best through "cookbook" method, Paulo Freire what he called "Banking Concept" where the children are the passive receiver and teachers continuously deposits knowledge into their mind.

Science is not to be taught by verbal method. Instead, emphasis is on first hand experimentation and observation. A shift is needed from teaching to learning. Learning should takes place on the cognitive, affective and psychomotor domains of learners. Pedagogy should follow Dewey's philosophies, ideas and thoughts of "learning by doing" and "learning through experiences". Dewey opined... continuity of experience motivates the learner to form an attitude and desire for continuous learning (Neil, 2003). Jean Piaget (1977) suggests that as a learner strives to organise personal experiences in terms of pre-existing mental schemes knowledge is constructed. Further he stated that cognitive development depends upon the factor called experience. The philosophy of constructivism also argues that the learners are not empty vessel; students come to school with previous knowledge and skills gained through their personal experiences. Crowther (1997) suggests that "as we experience something new we internalise it through our past experience. There is interplay between experience and learning. Experience plays important role in learning process; action is the fundamental doctrine of experiential learning".

The principle of constructivism is personal experience, student autonomy, active involvement, exploring the concepts, exchanging information using cognitive terminology, employing the process skills, raising questions and arriving conclusions etc. Experiential learning provides such type of climate to the learner to experience process of science. Amin (2012) stated that experiential learning is one of the constructive approaches. Accordingly, students must experience the science by doing hands on science experiments like handling the microscope to observe fine details (ex: Human Blood Cells, algae, fungi), observing the smell, texture, colour and smell of chemicals; noticing the similarities and differences between pictures or objects; observe the preserved plants and animals specimens; observe science experiments; using magnifying lens during observations; operating the science equipments. Such experiences can develop skill of observation. Children observe many things around them. After observation of things, materials and organisms, that is to be classified based on the similarities and differences. Experiential learning activities and environments provide such opportunity to classify the materials' or substances. Science is not only observable it is also measurable using standard measuring unit. Experiential learning facilitates the students to develop measurement skill by measuring the length mass weight temperature volume etc. While employing the skills such as observation, classification and measurement, students tend to discuss, share their observations and findings with other students through both verbal and non verbal method of communication such as tables' charts graphs symbols diagram etc. While involving in experiential learning activities such as hands on experience, field visit, role play, demonstration, multimedia presentation, simulation they can able to predict the future event and derive inferences by their own based on observations.

In a nut shell, by observing the research findings and committee's reports on science teaching it can be inferred that science teaching in schools are unsatisfactory, teachers often follows lecture method, students acts as passive listeners. Hands on learning experiences rarely or not provided to the students, results students were not in a position to expert in basic science process skills. John Dewey an educationist advocated that the learning should be experiential, he said that one can learn best by doing, accordingly learning should go beyond traditional lecture method; there should be rich learning experience wherein students actively participate in the learning process. Constructive based experiential learning provides such rich learning experiences for the students though which students can acquire knowledge and process skills.

1.11 Rationale

Science is universal and knows no boundaries, no absolute. It is future oriented and a disciplined way of seeking new knowledge for deeper understanding. Science is a part of school education and it act as a starting point for children intellectual and personal development results individual can prepare better life. School science prepares the children to understand basic scientific concepts and process skills and its application. It develop attitudes and values, also prepares the children to study science in higher education. It was stated by reports and documents that one of the main objectives of science teaching is development of process skills. Process and products are interrelated. Process approach leads to development of products. Harlen (1999) stated that the process skills and content of science are inseparable, "Process skills must be taught in relation to some type of content". Curriculum for science education (NCERT, 1990; NCF, 2000; NCF, 2005) also emphasising the process skills. Process validity is an important criterion since it helps in 'learning to learn' science. UNESCO (1992) report on "Developing New Teacher Competencies" also emphasised the process skills in many learning areas of the curriculum in all countries including India. UNESCO (2009) recommended that, to achieve MDG "Science in schools should provide concepts, skills, and processes.

Process skills are the foundation for constructing scientific concepts, scientific attitude, understanding the nature of science, science interest, curiosity towards science, problem solving, creativity. Rehorek (2004); Germann & Aram (1996) opined that development of science process skills enables students to construct and solve problems, critical thinking, deciding and finding answers to their curiosity rather than having the students to memorize the concepts. By employing these process skills students can clarify their doubt, modify their ideas, construct and reconstruct the concepts. If these process skills are not carried out in a rigorous and scientific manner then the emerging ideas will not necessarily fit the evidence; ideas may be accepted which ought to have been rejected, and vice versa (Harlen, 1995). There is a strong belief that children who are properly introduced to science through process skills will find the skills useful throughout life. It is possible to easily forget science content learnt but process skills tend to remain with many individuals for a relatively longer period, use of science process skills can increases the permanence of learning.

Science teaching plays a prominent role in knowledge construction and process skill acquisition. Conventional lecture method has no scope to develop process skills. Unfortunately, present science teaching in Indian schools is examination oriented, over domination of rote memorisation, teachers' centeredness, process aspects of science is largely ignoring, and students were not allowed to do practical part of science. Science teaching was not allowing the students to creativity and inventiveness (Umasree, 2003; Vaidya, 2003; NCF, 2005; CABE committee, 2005; NKC, 2006-2009). Findings of HSTP (1970-2002) a massive Science teaching programme revealed that "Science teaching is mainly textbook-based rote learning with little emphasis on understanding of concepts or the process of science, students are unfamiliar and far behind in basic process skill". In many classrooms today "teaching" means talking, and Learning means "listening".

Science teaching needs to be revised from teacher centeredness to student centred. Approach of teaching science to be broadened and it should facilitate the learner to be an active participant not a passive listener. Science Teaching should move away from rote learning. Teachers of science need to give ample scope for the students to expose themselves into hands on minds on experiences so that children can involve physically and intellectually in the learning process and acquire concepts and skills for their personal long term academic and personal success. Learning through one's own experience is more realistic, personal and meaningful. Experiential learning is one such a method facilitates the students to participate actively in the learning process for acquiring knowledge and skills. In this method learning takes place through experiential mode, teachers' role is to provide facilitation.

20th century Philosopher John Dewey (1938) who elaborated on the philosophy of learning from experience. He opined that "an experience exist because of the interaction between student and his/her experience". He attributed experiential learning movement in his educational philosophy. Carl Rogers (1961) said that "Experience is for me is the highest authority and the touchstone of validity is my own experience". Further he stated that Cognitive learning is meaningless and experiential learning is meaningful. According to Thorndike a behavioural psychologist "The behaviourist approach defines that learning as a relatively permanent change in behaviour that results from experience". David Kolb (1984) an educationist opined that experience as the source of learning and development. Eminent Educational theorist and psychologist Dewey, Lewin and Piaget emphasised the importance of experience in learning process and they laid down the intellectual foundation of experiential learning in all educational systems. National level and State level documents, Curriculum Frameworks for School Education, Teacher Education (eg. Report of the CABE Committee, 2005; Report of the Common School System Commission, 2007; Tamilnadu Common School Education Curriculum, 2009; School Education in Gujarat, 2006; NCF-2005 and NFCTE, 2009) also recommended experiential learning method. Research findings revealed that experiential learning is an effective and long-lasting form of learning where the learner involves by creating a meaningful learning experience (Beard, 2007). Hence, experiential learning method was adopted in this study for developing process skills.

The present study carried out among upper primary students of standard eight in the state of Tamil Nadu. The period of upper primary is one of the tremendous cognitive development, shaping reason, intellect and social skills, as well as the skills and attitudes necessary for entering into the work place. At this stage children are getting first exposure to learn 'science' as a separate subject; this is the stage to bring right perspective of what it means to "do science". Eighth standard is the threshold and it is a transition phase between primary and secondary education. It is a crucial stage wherein students receive higher level scientific inputs, and very significance in terms of promoting interest and attitude. At this stage Children willing to do experiments enthusiastically, critically observe, manipulate the variable, logically analyse and construct the scientific concepts and skills. According to Piaget eighth standard children are in formal operation stage (Twelve Years above) beginning of adolescence, students thinking is hypothetical, deductive and logical reasoning, ability to think abstractly, they argue, debate, ability to combine, classify items in a more sophisticated way, raise questions, observing the number of specific events and inferring an abstract, analysing the cause and effect (e.g. changing the length of string and weight of the pendulum) (Morgan et al, 1993). In this stage, emphasis on the process skills in science should continue to enable children learn how to learn for themselves, so that they could carry on learning to even beyond school (NCF, 2005). Objective of science teaching at this stage should stress more on the processes of science than the product so that they can generate and validate the scientific knowledge. If the students proficient in basic process skills, certainly helpful for developing higher level integrated process skills in their later stage of education. Thus, present study taken up in the students of standard eight.

Present study undertaken in the state of Tamilnadu. The state has achieved near universal access at both primary and upper primary levels. The GER and NER for Primary are 101.5 and 99.4 and for Upper Primary are 103.8 and 98.6 (World Bank Report, 2008). To improve the quality of school education state has taken enough measures in various curricular areas. One such measure is revitalisation of curriculum. Tamilnadu School Education System implemented new syllabus named as "Common Curriculum" (Samacheerkalvi) from the academic year 2011 from sixth to tenth standard. Also, under the direction of SSA across the State schools adopted has Activity Based Learning (ABL) transaction method of teaching for standard one to four and Active Learning Methodology (ALM) for standard sixth to tenth. By realising the importance of Experiential learning, Tamilnadu Common School Education Curriculum (2009) also recommended that learning should be experiential and need a shift to remove rote learning from text book. Keeping all these in mind, researcher carried out a study on science process skills in students of standard VIII with the following research questions.

1.11.1 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?

1.11.2 Statement of the Problem

Acquisition of Science Process Skills through Experiential Learning in Students of Standard VIII

1.11.3 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.

1.11.4 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 science process skills in Students of standard VIII.

1.11.5 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 experimenting, 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 VIIIth 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.

1.11.6 Delimitations 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.

This chapter presents the conceptual clarity on Science process skills and Experiential Learning. Also rationale, objectives, hypotheses, explanation of the terms, and delimitation of the study were included. The subsequent chapter depict the scenario of research studies in the area of science process skills and Experiential Learning.

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 area. 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 programmespecifically 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 then 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 reveals 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 developmentof 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 laboratorymethod, 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 the 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 Moural (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 Assessmentis 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 constructedtest 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 schools 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 11^{th}-grade and 12^{th}-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.

CHAPTER III
METHODOLOGY

3.1 Introduction

Methodology of the study provides in-depth knowledge about what type of methodology followed by the researcher in a particular study; it gives direction and suggestion for other researchers to adopt apposite methodology. This chapter included sample and sampling technique, tool and techniques adopted, design of the study and data analysis techniques.

3.2 Sample and Sampling Technique

Sample for the present study was students of standard eight (English Medium) from Gudalur Government Higher Secondary School situated in Gudalur Taluk, Nilgiri District, Tamilnadu. According to SSA mission Tamilnadu, Nilgiri District was identified as one of the special focus districts which require special attention with respect to school education. The literacy rate of Nilgiri District was 85.7% which is comparatively higher than Tamilnadu literacy rate 80.3% (Census, 2011). There are four educational blocks in Nilgiri District they are namely Ooty, Coonoor, Kotagiri and Gudalur (Picture_3.1). There are 724 schools in this district according to State Planning Commission, 2011 (table_3.1). For the present study, Gudalur Educational Block was selected. In this block 199 schools which include Government, private aided and private unaided. Out of 199 schools, Gudalur Government Higher Secondary School students of standard eight were selected purposively. The sample comprised of 28 students (7 Girls and 21 Boys). The purposive sampling method was adopted by considering the following requirements and criteria,

3.2.1 Criteria for Selection of School

1. The school which is ready to provide permission for one complete academic year (2011-2012) to develop process skills through experiential learning.
2. Cooperation from the teachers and Head Master to carry out research throughout the year.
3. Well-equipped multimedia theatre facility.
4. Large sized classroom and laboratory facilities so that group wise students can be engaged in Kolb's experiential learning cycle for doing science experiments.

Picture_3.1: Educational Blocks in Nilgiri District

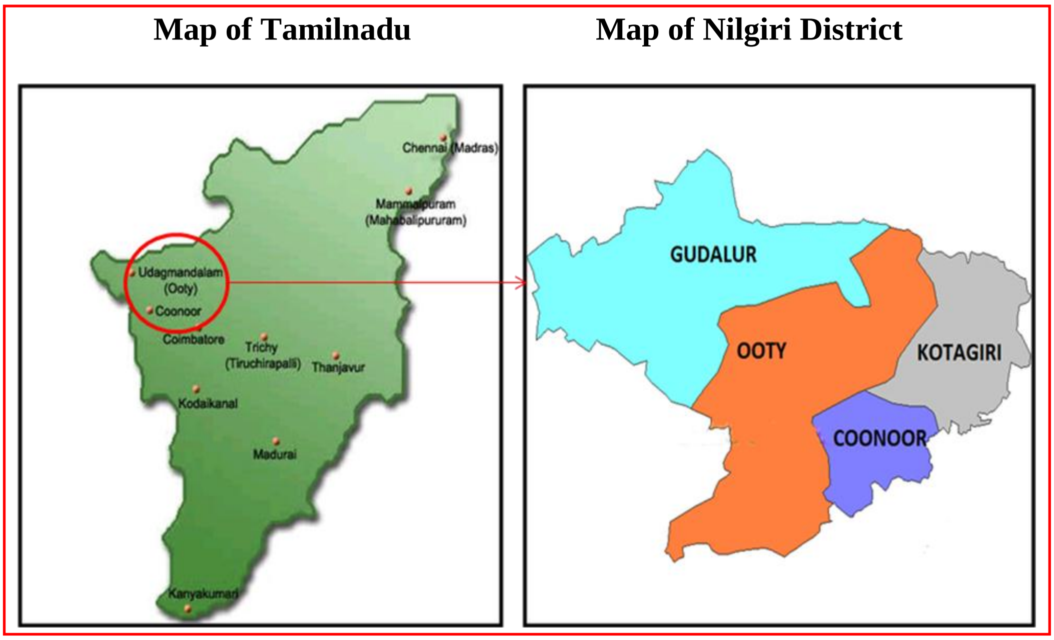


Table_3.1: Number of Schools in Nilgiri District

	Educational Block	Govt/Local body	Private Aided	Private Unaided	Others/ KGBV	Total Schools
1	Ooty	150	40	50	11	251
2	Coonoor	68	61	30	13	172
3	Kotagiri	62	20	16	04	102
4	Gudalur	136	18	41	04	199
Total		**146**	**139**	**137**	**32**	**724**

Source: Annual work plan and Budget 2010-2011, SSA

3.2.2 Description about School

Gudalur Government Higher Secondary School was established in the year of (1948) which is located in head quarter of Gudalur taluk (Appendix_8.1). The school having enough space with good infrastructure facilities such as large size play ground, separate computer room, multimedia theatre, adequate toilet facilities for boys and girls, adequate drinking water facility, each grade having separate classroom, no multigrade classroom system, and having separate laboratory for Secondary and Higher secondary students. There were one thousand five hundred and twenty students from sixth to twelfth standard studying in Tamil, Malayalam and English medium during the academic year 2011-12. Total numbers of teachers were forty. Out of forty, thirty five teachers were permanent and five teachers were temporary; all the teachers were professionally trained.

3.3 Sources of Data

Data were collected from students, teachers, Head master, parents and siblings of sampled students by using various tools and techniques. Data pertaining to basic science process skills obtained from students. Data related to profile of school obtained from Headmaster. Data with regard to the effectiveness of experiential learning intervention programme were obtained from sampled students, teachers who are teaching different subjects for sampled students, and their parents and siblings.

3.3.1 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. Close ended questionnaire for Students
4. Rating Scale for Students
5. Observation Technique by researcher to observe student behaviour
6. Semi Structured Interview with Students, Parents and Siblings
7. Focussed Group Discussion (FGD) with Teachers
8. Video graphy and still photography

3.4 Tools Construction

From the above mentioned tools and techniques, following tools such as open ended questionnaire, close ended questionnaire, rating scale were constructed by researcher. The descriptions of construction of tools are presented below.

3.4.1 Open Ended Questionnaire for Students

In order to collect the data on science process skills from the selected sample, researcher constructed open ended questionnaire for the students of standard eight. Separate questionnaire was constructed for each process skills such as observation, classification, communication, measurement, prediction and inference. By considering the study objectives, research questions, nature of date required, and students cognitive level, researcher followed the steps of questionnaire construction given by Mouly (1979). In first step: in order to conceptualise in-depth knowledge about process skills and assessment procedure of process skills, researcher gone through the books, related literature, journals and articles. Then the indicators of each process skills were identified and listed out for questionnaire construction. In second step: further interacted and discussed with experts and scholars to make the questionnaire more effective and to collect the complete data on process skills. In third step: researcher delimited only to basic science process skills indicators for getting valid data on those skills. In fourth step: A rough draft questionnaire was prepared for each basic process skill such as observation, classification, communication, measurement, prediction and inference. The items in the questionnaire consist of all the indicators of basic science process skills. Most of the items in the questionnaire were chosen from sixth, seventh and eighth standard Science textbook of Tamilnadu, few items selected from other text book like UNESCO source book for science and NCERT book. Hence contents of the text book used as medium to assess basic science process skills. The questionnaire was strengthened and ensured that all the items accomplish the objectives of the study. In fifth step: developed tool was sent to the subject experts for validation to ensure the content validity, process validity, and appropriateness of items (Appendix_6.1: List of names of experts). The tool was validated by experts, suggestions and comments were incorporated. In sixth step: The constructed and validated questionnaire consists of 115 items and it was piloted in the students of standard eight. The description of pilot study is as follows.

3.4.2 Piloting of Open Ended Questionnaire

Pilot study was conducted among the students of standard eight in St Thomas Higher Secondary School Gudalur, The Nilgiris following English Medium State Board syllabus (Plate_3.1). According to Johnson and Christensen (2008) researcher should conduct pilot test minimum of five to ten pupil. Accordingly, eight students were selected from standard VIII. Those eight Students have been selected based on their previous year academic performance. The selected students heterogeneous in nature i.e. slow learners, average and gifted students.

Plate_3.1: Pilot Study

Measuring the Volume of $KMnO_4$ Solution	*Measuring the Temperature of Water*
	

While piloting the tool there were 115 items in the questionnaire. Subsequent to completion of pilot test researcher used “Think aloud Technique” to know strength and weakness of the questionnaire. In this technique the participants verbalise their suggestions and perceptions about each items. Think aloud technique is for determining whether participants are interpreting the items the way researcher is intended (Johnson and Christensen, 2008). Based on the participants’ opinions and responses some of the items were deleted, few items were substituted, finally total number of items reduced from 115 to 100 (table_3.2).

Table_3.2

Total No. of Items in Each Process Skills before and after the Pilot Study

Sr. No	Basic Science Process Skills	No. of Items during Pilot study	No. of Items deleted after Pilot Study	No. of Items Added after pilot Study	Total No. of Items for actual Study
1.	**Observation**	20	08	04	16
2.	**Classification**	20	02	-	18
3.	**Communication**	17	04	03	16
4.	**Measurement**	20	02	-	18
5.	**Prediction**	18	02	-	16
6.	**Inference**	20	04	-	16
	Total	**115**	**22**	**07**	**100**

3.4.3 Finalised Open Ended Questionnaire

In the final form of questionnaire there were 100 items. Utmost care has been taken to cover items from both physical sciences and biological sciences. Most of the items in the questionnaire were performance based wherein students need to perform the experiments and then they wrote responses. Some of the items were activity based wherein students observed the picture and demonstration then they responded

3.4.4 Principles followed while Constructing Open Ended Questionnaire

- The researcher be broad while framing the questions and did not miss any important skill that the research participant feel relevant.
- Prior to construct the questionnaire researcher carefully reviewed the existing research literature, as well as all related instruments that have already been used by other researchers on process skills.
- The researcher considered students' age level and their cognitive development.
- Language used in the questionnaire was simple and understandable by the students i.e. Jargon or technical terms were avoided.
- Double barrelled questions were avoided.
- Researcher followed ordering of items in the questionnaire. Positive and easy items are kept first so that students get motivated to answer.

3.4.5 Construction of Close Ended Questionnaire for Students

Close ended questionnaire was constructed by researcher for sampled students to know their achievement on basic science process skills. Researcher has followed steps of questionnaire construction given by Mouly (1979). Constructed questionnaire consist of 35 multiple choice items which covers all basic science process skills such as observation classification communication measurement prediction and inference (Appendix_3.1). The self constructed questionnaire was validated by experts (Appendix_6.1). Experts Suggestions and comments were incorporated.

3.4.6 Construction of Rating Scale for Students

Four point rating scale (Always, Sometimes, Rarely, Never) was constructed by the researcher for the selected sample to know the status of basic science process skills. There are sixty items which includes observation, classification, communication, measurement, prediction and inference skills (Appendix_4.1). The self constructed rating scale was validated by experts (Appendix_6.1).

3.5 Design of the Study

Present study design was developmental cum experimental. Developmental refers that researcher developed basic science process skills among the students in one academic year through experiential learning intervention programme; experimental refers that to what extent implemented programme was effective in terms acquisition of basic science process skills. Design of the present study consists of three phases which are described below

Phase I	**Study the existing status of BSPS before Implementation of Intervention Programme**
Phase II	**Development and Implementation of Intervention Programme**
Phase III	**Assess the BSPS after implementation of Intervention Programme**

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

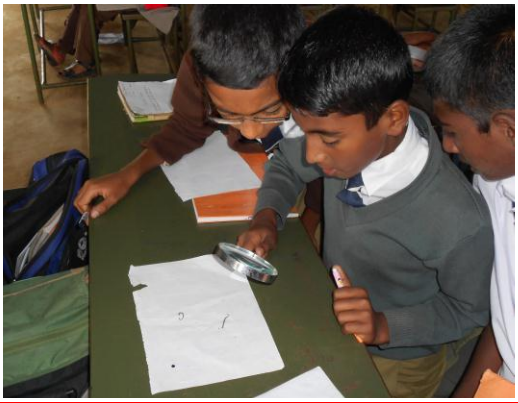
In this phase, in order to know the existing status of Basic Science process skills, self constructed tools and techniques are administered to the sampled students. The description of administration of tools and techniques are as follows.

3.5.1.1 Administration of Situational Test for Students

Situational test was administered for the students of standard eight. Students were divided into groups, in each group 4 to 5 students. Students had been provided earthworms and shoe flower with hand lens for observation and communication skills. Students' observed the earthworm and shoe flower. Similarly, to know the status of measurement skill, umbrella and spring balance had been provided to measure the weight (Plate_3.2).

Plate_3.2: Situational Test

Observation of Earthworm



Measuring the Weight

3.5.1.2 Administration of Open Ended Questionnaire for Students

Self constructed open ended questionnaire was administered to find out the existing status of process skills. Clear verbal instruction has been given in detail about each item prior to write responses. The detail description of administration of each questionnaire is described below:

Observation Skill: There are 16 items in this questionnaire (Appendix_1.1). For item numbers 1, 4, 12 and 14, pictures are shown in the questionnaire, students observed then they responded. For Item number 2, a glass of water with pencil and a coin kept in it for observation. Item number 3, lighted candle kept for observation. Item number 5, real specimens (Ginger and potato) provided for observation. Item number 6, decayed bread and magnifying lens provided for observation (Plate_3.3 (a)). Item number 7, thermometer was kept in a beaker containing water to observe the mercury level in the thermometer.

Plate_ 3.3 (a)Observation of decayed bread

For item no 8, preserved specimen (centipede) provided to observe. Item numbers 9, chemicals were placed on the table (*Plate_3.3 (b)*. Item number 10, audio on Saturn planet was played in the computer for listening, after completion of audio, questions were written on the blackboard to know what they have listened. Item number 11, Human blood slide was kept it on the microscope, students observed the slide, the they responded *Plate_3.3 (c)*. For Item number 13, sand was kept for observation. Item number 15, preserved specimens (Spider) with magnifying lens was kept on the table. Item number 16, real a plant specimen was provided for observation. Students observed the specimens, chemicals, sand and real specimens' one after another. No time restriction for the students to observe the specimens, slides, chemicals etc. They have taken their own time to observe.

Plate_3.3 (b): Observation of Chemicals

Plate 3.3 (c): Observation of Human Blood

Classification Skill: there are 18 items in this questionnaire (Appendix_1.2). For item numbers 3, 10, 12, 14, 16, Pictures are shown in the questionnaire, students classified the things, objects, organisms as per the instruction given in the questionnaire. For Item numbers 7 and 8, plants and animals pictures were shown in the computer to classify them based on the similarities and differences. For item number 11, soluble, insoluble and slightly soluble substances were shown to them for classification. Item number 15, acid and base substances were shown. The item numbers 1, 2, 4, 5, 6, 9, 13, 17 and 18, things, substances, elements and solutions which are listed in the questionnaire, students were classified them into different groups based on the common attributes or characteristics.

Communication Skill: There are 16 items in this questionnaire (Appendix_1.3). For Item numbers 1, 6, and 7, graph sheet had been provided to plot the graph for the given data. For item number 10, Human heart diagram chart was hanged on the wall, students drew the same. For item number 12, Human brain model was displayed to draw and label it. Remaining Item numbers 2, 3, 4, 5, 8, 9, 11, 13, 14, 15 and 16, were to write symbols, equation, draw flowchart, pie chart, and bar diagram, to draw tables etc as per the instruction given in the questionnaire. Clear instruction was given to them about each item before responding to the items, however Students raised few questions and the same was clarified by the researcher.

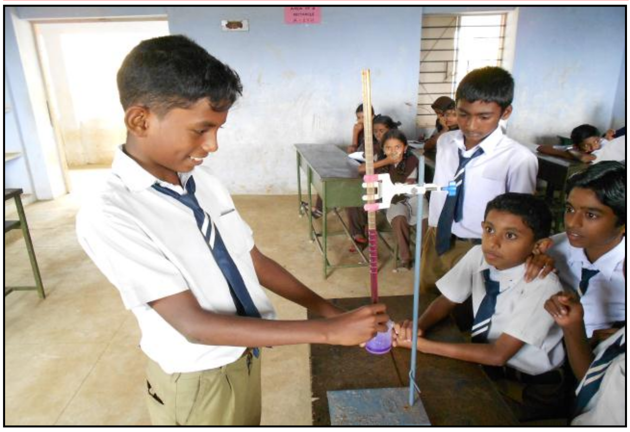
Measurement Skill: There are 18 items (Appendix_1.4) in this questionnaire to quantify or measure the objects or liquid using appropriate measuring devices. Questionnaire was distributed to all students, and clear verbal instruction had been given in detail. First, students attempted the following items 1, 2, 4, 5 and 15 because these are the items to measure the length, breadth and height, angle of the diagram shown in the questionnaire, after completion of the above items they were engaged to attempt rest of the items numbers 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, and 18. Item number 3, to measure the volume of water measuring cylinder with water and separate beaker were provided to them. Each student called one after another for measurement, as soon as they completed researcher immediately noted in their questionnaire about the volume of water they measured. Item number 6, to measure the total area of irregular leaf, researcher has given a leaf and graph sheet to the students, the same leaf was circulated to all students to draw outline of leaf on the graph (*Plate_3.4 (a)*). Then they measured the total area of leaf. Item no 7, students measured the weight of a bag with books by using pointer balance. Item no 8, a glass with hot water and cold water provided separately to measure the temperature of water by using thermometer.

Plate_3.4(a) Measuring the total area of leaf

Item no 9, desk was placed in the classroom students measured the length, breadth and height by using measurement device (tape**)** (*Plate_3.4 (b))*. Item no 10, to determine the volume of irregular object (stone), one litre graduated beaker with water and a stone tied with thread were placed on the bench, students measured the volume of stone. Item no 11, simple pendulum experimental set up with scale was placed on the table, students measured the length of the pendulum. Item no 12, cloth and measurement tape was provided to them to measure the length and width of the same. Item no 13, a burette with potassium permanganate solution ($KMnO_4$) was kept in a stand, students were asked to take exact 15 ml of $KMnO_4$ solution in a beaker (*Plate_3.4 (c)*, thereafter researcher immediately noted down in their questionnaire about the amount of $KMnO_4$ solution they measured. Item no 14, students were engaged to measure exact 20 ml of water using pipette tube, after measurement researcher noted down in their questionnaire about how much water they have taken exactly. For item no 16, students measured the classroom temperature by using Fahrenheit and Celsius thermometer. For question no 17, thread had been given to measure the curved line diagram shown in the questionnaire. Item no 18, post card was given to everyone to measure the length and width of the same.

Plate_3.4 (b) Measuring the table

Plate_3.4 (c) Measuring the Volume of $KMnO_4$



Prediction Skill: There are 16 items in this skill (Appendix No_1.5). Items are based on students' daily life experiences and observations. Before responding the questions, clear instruction was given about each item. First, students predicted for the following Item numbers 1, 3, 4, 6, 10, 11, 12, 13, 14 and 16 because these are the items can be predicted based on previous experiences. Rest of the items numbers 2, 5, 7, 8, 9, 15 students observed the experiments then they predicted. For item no 2, simple pendulum experiment was performed by the researcher (*Plate_3.5(a)*) then the students predicted for item no 2 (a), (b) and (c). Item no 5, researcher had shown two joined plane mirrors at different angles to predict the angle between two mirrors. Item no 7, cold water and warm water were given separately in two beakers to touch and predict the temperature. Item no 9, different liquids such as coconut oil, kerosene, petrol, honey and water had shown to them to predict miscibility and immiscibility of liquids. Item no 15, Students observed the clouds, moisture and climate outside the class for few minutes, also they recalled the past two days weather report. Based on the observations of climate outside and past two days experiences students predicted that the same day evening going to be rain or not.

Plate_3.5(a) Simple pendulum Experiment for Making Prediction

Plate_3.5 (b): Experiment to predict the angle between two mirrors

Inference Skill: There are 16 items in this skill (Appendix_1.6). First, students' wrote inference(s) for the following item numbers 2, 6, 7, 14 and 15 because inferences can be derived based on the observations of pictures shown in the questionnaire. The item numbers 1, 3, 4, 5, 8, 9, 10, 11, 12, and 13, students derived inference(s) after observing the experiments. Item no 1, students were observed the experiment kept for observation, then they derived inference(s). Item no 3, soluble and insoluble substances (Wood powder, dust, iron powder, sand and common salt) experiment was performed Plate_3.6 (a) then they derived inference(s). Item no 4, acid base test was shown based on the observations of colour change, students' derived inference (s). Item no 5, student demonstrated experiment on conduction on heat in solids (*Plate_3.6 (b)*) then they derived inference(s). Item no 8, student demonstrated the experiment on floatation of following liquids such as Kerosene, castor oil, diesel, honey in water, then they derived inference(s). For Item no 9, researcher demonstrated the experiment on absorption of heat by water, based on the observations of experiment students' derived inference (s). Item no 10, simple pendulum experiment was demonstrated by researcher, based on the observation students' derived inference(s). For Item no 11, students performed the activity, and then they derived inference(s) based on observation. Item no 12, researcher demonstrated an experiment on neutralisation of bases by adding acids and derived inference(s). Item number 13, experiment on change of states of matter was demonstrated in front of students for observation, based on observation students derived inference(s). Item no 16, video on different types of levers was shown on the computer for making inference(s).

Plate_3.6 (a) Experiment on Soluble and Insoluble Substances in water

Plate_3.6 (b) Experiment on Conduction on Heat

3.5.1.3 Administration of Close Ended Questionnaire for Students

To know students achievement on basic science process skills, self constructed close ended questionnaire was administered to the students of standard eight. There were thirty five multiple choice items with four options (Appendix_3.1), Students put tick mark for one correct response. Thirty minutes time duration has been given for completing the questionnaire.

3.5.1.4 Administration of Rating Scale for Students

Self constructed four Points rating scale (Always, Sometimes, Rarely, Never) was administered to the students of Standard eight. There are sixty items, to complete the entire items in the rating scale Ninety minutes time duration was given.

3.5.1.5 Semi Structured Interview with Students

Semi structured interview was conducted with the students of standard eight. The main focus of interview was to know whether they employed process skills in earlier class, and status of science teaching in the previous standard. Interview was conducted in one hour, semi structured questions were posed during group interview and further probed (Appendix_5.1).

3.5.1.6 Participant Observation by the Researcher

As a participant, researcher observed behaviour of students during administration of questionnaire and the same was noted down in the field notes.

3.5.1.7 Photography and Videography

During administration of questionnaire still photography and videography was used to record their performance and behaviour.

To administer the tools and techniques, twenty School working days (everyday 90 minutes) were used. During the period of administration of tools and techniques science subject was not taught to the students by the regular teacher or researcher.

3.5.2 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.

3.5.2.1 Development of Intervention Programme

- It is no doubt that Science can be best learned through laboratory experiments. Procedural way of knowing science is more concrete and meaningful than the declarative knowledge. Simple hands-on experiments and activities are more important to employ the process skills. Students need to engage in various learning experiences in appropriate learning environment so that they observe, record, analyse, communicate, measure predict and infer etc. Teaching of science should engage in hands-on experience and activities, simulated models, field visit, ICT based learning, model making, projects, group discussion, demonstration, role play, laboratory visit etc. Experiential mode of learning provides such type of learning experiences to the students to acquire knowledge and process skills. Research findings also revealed that constructive approach demonstration, environmental approach, activity based method developed science process skills (Ramkumar, 2003; Amin, 2011; Bhaskar, 2010). NCF (2006) position paper on Science teaching also recommended the experiential mode of learning. By keeping all these view in mind, researcher developed an intervention programme based on Kolb's experiential learning cycle.
- Prior to develop an intervention programme, researcher analysed the contents of Tamilnadu State science textbook of standard eighth, all the activities and experiments related to the contents were included in the intervention programme; in addition to that, some of the experiments and activities taken from other science source books for example UNESCO resource book for science by considering the following aspects such as age and cognitive maturity of students of standard eight, relevant contents, simple experiments which cover most of the basic science process skills. Hence, the science contents were the medium for developing process skills.
- The selected experiments and activities were 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.
- Developed programme was sent it for validation and it was validated by the experts (Appendix_6). After validation, the programme was finalised to implement in the academic year of 2011-2012. Meanwhile in the same

academic year (2011) Tamilnadu State School Education introduced new revised Science Curriculum entitled on "Common Curriculum" (Samacheer kalvi). According to new syllabus (Common Curriculum), changes were made in the intervention programme in terms of incorporation of some concepts, experiments/activities. Then the revised intervention programme was implemented in the academic year 2011-12, the detail description of implementation of programme is as follows.

3.5.2.2 Implementation of Intervention Programme

- The programme was started to implement in the month of August 2011 and it continued till February 2012. During the period of implementation of Intervention Programme regular science teacher not engaged in teaching science and other activities such as science note correction, book correction, and examination supervision for the sampled students, the entire science syllabus was taught by researcher.
- Before implementing the programme researcher discussed with science teacher and other subject teachers who are regularly teaching to the sampled students to know each student's academic performances in science. Based on the teachers' opinion, students had been divided into six groups. Each group consist of five students but in one group there were three students. However the number of groups and number of group members was slightly varied depending upon the experiments and activities. Each group was heterogeneous in nature wherein slow learners and gifted students were placed so that everyone can be participated actively.
- During the period of implementation of intervention programme, the group was framed twice and the group members were reshuffled to develop the socialisation among the students and between the students. The programme was implemented in every day two science periods between 11: 30 am to 1:10 pm (except Every Wednesday). In addition to usual science period, researcher used other periods in case of absence of concern subject teacher.
- Intervention Programme includes hands on experience, simulation, role play, demonstration, multimedia presentation (virtual class experience) and field visit which follows Kolb's Experiential Learning Cycle.

- During Hands on Experience: Group wise students made to sit separately to do experiments in the classroom as well as in the laboratory. Required apparatus were provided and clear instruction given to them with regard to name of the experiment, objectives, procedure, and process skills to be developed. As per the instruction each group engaged in doing different experiments; after completion of given experiment by all the groups, they were shifted to do other experiment, likewise group rotation was done till completion of all the experiments by all the groups.
- While doing experiments students started with any one of the stages of Kolb's Experiential Learning Cycle and followed other stages. Most of the experiments students started from first stage of the cycle called Concrete experiences (CE) and they followed others stages such as Reflective Observation (RO), Abstract Conceptualisation (AC) and Active Experimentation (AE). For some experiments Students begins with Active Experimentation (AE) stage and followed all other stages of cycle. During experimentation, in each stage of the Kolb's cycle students acquired the basic science process skills. Utmost care has been taken to focus all the groups for enhancing process skills.
- In Multimedia Presentation (Virtual Class Experience): Certain Videos on were shown to the students in multimedia theatre with sound effects for acquiring the process skills and concepts. For example different types of glands and hormones in human body; different types of human cells and CRT tubes etc are the videos were shown in multimedia theatre.
- In demonstration: Researcher has demonstrated the experiments which are little hazard to the students (e.g heating of chemical substances), and the same experiments were performed by students.
- In simulation: group wise students prepared some of the simulated models, for example, cell and its organelles, types of irrigation and the same was presented in front of students. Videos of the same models were also shown through multimedia presentation.
- In role play: Students performed different role. For example, they played a as the role of element, and compounds, chemical formula, and valency of a particular chemical compound.

- In field visit: Researcher taken the students to the field for observation, first they visited natural biodiversity garden called "Gene Pool". In this garden, medicinal plant, aquatic plants, xerophytic plants were observed; also they observed preserved animals such as snakes, lizards; insects etc were displayed in museum. Similarly, students were taken to field "vermiculture form" (Earth Worm Culture). This is the seasonal culture in which earthworm was cultured in separate culture medium.

In the above learning experiences, students followed each stage of Kolb's Experiential Learning cyclic. In each stage of the Kolb's cycle, students process skills was acquired.

3.5.3 Phase III: Assess the BSPS after Implementation of Intervention Programme

After implementation of intervention programme, students' basic science process skills status was assessed with the help of following tools and techniques.

1. Open ended questionnaire for students
2. Closed ended questionnaire for students
3. Rating scale for students
4. Observations technique by researcher to observe Students behaviour
5. Photography and Video recording
6. Semi Structured Interview with sample and non sample
7. Semi structured interview with Parents and Siblings
8. Focussed Group Discussion with Teachers (FGD)

Of the above tools and techniques, administration of open ended questionnaire, close ended questionnaire, rating scale were already described in phase I (pre intervention programme). Remaining techniques such as semi structured interview with sample, semi structured interview with non sample, semi structured interview with siblings and parents, Focus Group Discussion with Teachers, and participant observation are described below in detail.

3.5.3.1 Semi Structured Interview with Students (Sample)

Semi structured interview was conducted with students of Standard eight to know acquisition of basic science process skills through intervention programme. The interview was conducted an hour, semi structured questions were asked and further probed (Appendix_5.2) to elicit their attitudes, opinions and feelings about intervention programme. The entire interview was recorded and photographed.

3.5.3.2 Semi Structured Interview with Students (non Sample)

Semi structured interview was conducted with students of standard eight Tamil medium who were not participated in the study but studying in the same school. The main focus of group interview was to know their knowledge about basic science process skills because these students interacted with present study sample and discussed about various learning experiences and process skills. There were fifty students in the class at the time interview. Semi structured questions were asked and further probed (Appendix_5.3). Interview went on forty five minutes, and the responses were video graphed (Plate_3.7).

Plate_3.7: Semi Structured Interview with Students (non Sampled)

3.5.3.3 Focussed Group Discussion with Teachers

Focussed group discussion (FGD) was conducted with teachers who are taking different subjects to the students of standard eight. The purpose of FGD was to know teachers opinion on intervention programme and students process skills acquisition because researcher implemented the intervention programme in one academic year, present study students (sample) discussed with teachers with regard to intervention programme and process skills acquisition. To know teachers opinion, FGD was conducted. There were twelve teachers and all students of standard eight (Sample) participated in FGD. Discussion was continued forty five minutes; teachers shared their ideas, experiences, opinions and suggestion about intervention programme and the same was recorded (Plate_3.8).

Plate_3.8: Focussed Group Discussion with Teachers

3.5.3.4 Semi Structured Interview with Parents and Siblings

Semi structured interview was conducted with parents of and siblings of sampled students (Standard eight) to know the opinion on intervention programme. During the period of implementation of intervention programme, students shared their learning experiences with parents and siblings. Thus, researcher visited to parents' of sampled student's home for conducting face to face interview. Out of twenty eight parents, eighteen parents were interviewed based on readiness and availability. Some of the students' siblings who are studying in the same school also interviewed along with parents. The interview was conducted thirty to forty minutes with each parent wherein semi structured questions was posed and further probed (Appendix_5.4). The whole interview was photographed and video graphed.

3.5.3.5 Participant Observations by the Researcher

The entire data collection process, i.e. (i) before implementation of intervention programme (ii) during implementation of intervention programme (iii) after intervention programme. Researcher observed students behaviour and it was noted down in the field notes.

3.5.3.6 Photograph and Video record

Photograph and video record was used during the entire process of data collection (Before, during and after the intervention programme).

During the period of data collection, researcher had been there in the school every day by 9:30 am to till evening 4.00 pm, and engaged in some of the school regular activities such as examination supervision; during programme implementation botany subject was taught for eleventh standard and some chapters in science for tenth standard students.

3.6 Data Analysis

For the present study, data were collected by both quantitatively and qualitatively. Quantitative data were collected through close ended questionnaire and rating scale. Whereas qualitative data were collected through open ended questionnaire, situational test, observation, FGD, semi structured interview responses. Thus researcher employed mixed method of data analysis. According to Jhonson and Christensen (2008) if the data includes both qualitative and quantitative which are normally termed as "multidata", and these data first classified, and analysed concurrently or sequentially. Accordingly researcher classified qualitative and quantitative data and analysed sequentially.

Quantitative data obtained through closed ended questionnaire, and it was analysed by paired t-test (single group), similarly data collected through rating scale was analysed by chi square (2x4 contingency). The data collected through situational test, observational techniques, interview and focus group discussion (FGD) were analysed qualitatively by following qualitative data analysis techniques such as content analysis, data reduction, data display, and transcription of data.

The data collected through open ended questionnaire was analysed by analytic rubric developed by researcher. According to Yager (2008) Rubric can be holistic, generalised, and analytic. Holistic rubric is for assessing the entire task as a single entity or construct. Generalised rubric is to consider the dimensions of a task as single entity. Analytical rubric is for identification of individual knowledge and skills features critical to and inherent in a task to assess concept understanding, process skills, and habits of mind as separate components. For the present study, researcher developed analytic rubric for each basic process skill such as observation, classification, communication, measurement, prediction and inference to assess individual student performance in each skill (Appendix_2.1 to 2.6). Analytic rubric is useful to provide information about each student's level of performance in each skill. The following steps were involved while designing and developing the analytic rubrics.

1. Identification of Parameters to be Assessed: first, parameters in each process skill to be assessed was identified from open ended questionnaire, and all the parameters are listed in the left hand side of each rubric (for example: in observation skill: observing the similarities and differences between plant cell and animal cell is a parameter. similarly in classification skill: classification of things and objects into conductors and insulators is a parameter. Likewise all the parameters of each skill listed in each rubric).

2. Setting the performance level: Secondly, levels of performance were set in the rubrics**.** The number of rating levels depending upon the purpose and context of assessment, typically rubrics has three to six rating levels (Stevens and Kennath, 2007). In these analytic rubrics, four rating levels were used namely beginning stage, developing stage, accomplished stage, and proficient stage. The rating level starts from least performance to most performance, or poor performance to excellent performance, no marks or scores given for any of the rating levels.

3. Description of levels of ratings: The levels of performance in the rubrics categorised into four ratings (Beginning Stage, Developing Stage, Accomplished Stage, and Proficient Stage) which are presented in ascending order i.e. starts from the lowest levels of performance to the highest levels of performance of skill exhibited by a student. Description is given under each levels of performance corresponding to the parameters of each skill. Each description is differs from one level to another, Students' poor performance description in Beginning stage, somewhat good performance description in Developing Stage, good performance presented in Accomplished Stage, and excellent performance description in Proficient Stage. Based on the above three steps, the rubrics was developed and used it for analysis of open ended questionnaire. The procedure of rubric analysis is presented below.

The collected data with the help of open ended questionnaire was analysed both item wise and skill wise. First, item wise students responses provided in the open ended questionnaire were analysed with the help of rubric (For e.g. percentage of students in Beginning stage, Developing stage, Accomplished stage, and Proficient stage in each item under each skill). Secondly, students overall percentage was calculated in each skill (For e.g. percentage of students in

Beginning stage, Developing stage, Accomplished stage, and Proficient stage in each skill).

Data collected through semi structured interview with students and parents, focussed group discussion (FGD) were analysed by triangulation of data.

Table_3.3: Tools and Data Analysis Techniques

Objectives	Tools and Techniques Used for Data Collection	Analysis Techniques Employed
Objective No. 1 To find out the status of Basic Science Process Skills.	▪ Situational test	▪ Content analysis
	▪ Open ended questionnaire	▪ Analysed by Rubrics
	▪ Closed ended questionnaire	▪ Paired t test
	▪ Rating scale	▪ Chi Square (2x4 Contingency)
	▪ Participant Observation (Field notes and Video recording).	▪ Content Analysis
Objective No. 1&2 Development and Implementation of Intervention Programme.	▪ Participant Observation	▪ Qualitative analysis
Objective No. 4: To assess the acquisition of process skills after Intervention Programme.	▪ Open ended questionnaire	▪ Analysed by Rubrics
	▪ Closed ended questionnaire	▪ Paired t test
	▪ Rating Scale	▪ Chi Square (2x4 Contingency)
	▪ Participant Observation	▪ Content Analysis
	▪ Interview with students	▪ Triangulation of data
	▪ Focus Group Discussion	
	▪ Interview with parents	

This chapter described about the methodology adopted for the present study. The subsequent chapter describe the analysis and interpretation of data.

CHAPTER IV
DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

The purpose of this study was to develop science process skill in the students of standard eight through experiential learning. In the previous chapter, selection of sample, tools and techniques used, and design of the study, data analysis technique were presented in detail. This chapter reports analysis and interpretation of data. Owing to the nature of present study, objectives wise data was analysed and interpreted.

4. 2 Status of Basic Science Process Skills before Intervention Programme

4.2.1 Responses Provided in the Situational Test

While analysing the situational test, it was observed that most of the students' observations on shoe flower and earthworm was superficial, they just observed the colour of shoe flower, and colour of earthworm, also diagram of the same drew correctly to some extent. Though the hand-lens was given to them for observations, they could not notice certain quantitative observations, for example; number of petals in shoe flower, nature of body and number of body segments. Similarly, while weighing the object (3.5 kg umbrella), most of the students could not measure the weight of object precisely, they committed instrumental and measurement error. After measurement, students did not write correct measurement unit. With regard to prediction, most of the students correctly predicted about the rain but could not write reason for their prediction. From the analysis of situational test, it can be inferred that students' process skills was in beginning stage.

4.2.2 Responses Provided in the Open Ended Questionnaire

Collected data from Students with the help of open ended questionnaire was analysed both item wise and skill wise by using rubrics. The table from 4.1 to 4.6 shows item wise and skill wise analysis.

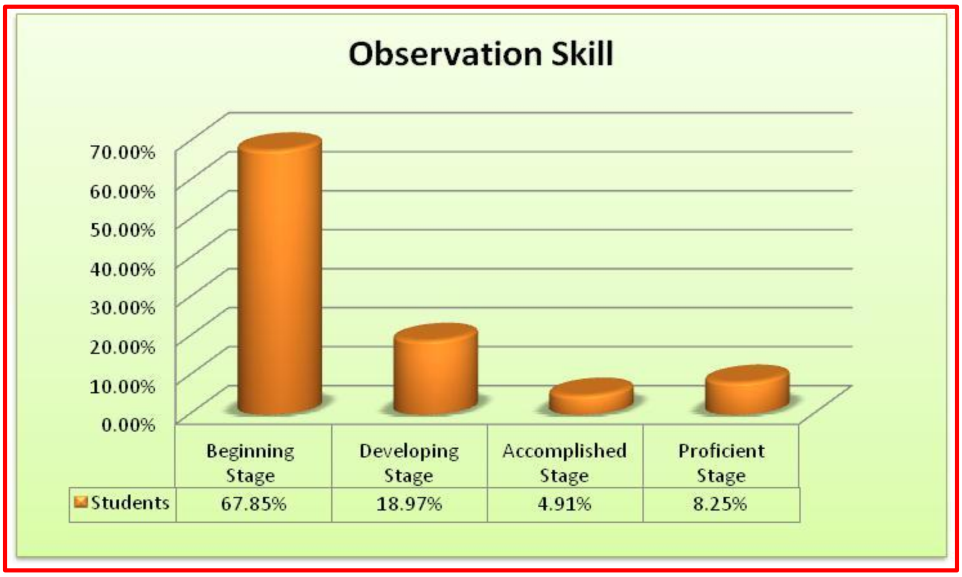
Table_4.1: Performance of Students' in Observation Skill

Item No	Parameters of Observation Skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplished Stage	% of Students in Proficient Stage
1	Similarities and difference between plant cell and animal cell	(24) 85.71%	(03) 10.71%	-	(1) 3.57%
2	Observation of pencil and coin in a glass with water	(12) 42.85%	(10) 35.71%	(02) 7.14%	(04) 14.28%
3	Observation of flame of lighted candle	(21)75%	(03) 10.71%	(02) 7.14%	(02) 7.14%
4	Similarities & differences of parenchyma and sclerenchyma cell	(26) 92.85%	(02) 7.14%	-	-
5	Differences between ginger and potato	(25) 89.28%	(02) 7.14%	-	(1) 3.57%
6	Observation of decayed bread	(26) 92.85%	(02) 7.14%	-	-
7	Observing the mercury level in the thermometer.	(25) 89.28%	(02) 7.14%	-	(1) 3.57%
8	Observation of preserved Centipede specimen	(15) 53.57%	(05) 17.85%	(03) 10.71%	(05) 17.85%
9	Observation of Chemicals	(17) 60.71%	(10) 35.71%	-	(1) 3.58%
10	Listens audio on Saturn planet	(18) 64.28%	(03) 10.71%	(05) 17.85%	(02) 7.14%
11	Observation of Human Blood tissue slide in microscope	(27) 96.42%	(1) 3.57%	-	-
12	Observation of aquatic succession picture	(08) 28.57%	(05) 17.85%	(02) 7.14%	(13) 46.42%
13	Observation of sand.	(17)60.71%	(06)21.42%	(02)7.14%	(03)10.71%
14	Observing the thermometer in the beaker	(13) 46.42%	(14) 50.%	(1) 3.57%	-
15	Observation of preserved spider specimen.	(11) 39.26%	(13) 46.42%	(02) 7.14%	(02) 7.14%
16	Observation of a plant (real specimen)	(19) 67.85%	(04) 14.28%	(03) 10.71%	(02) 7.14%
Overall Performance		67.85%	18.97%	4.91%	8.25%

From the table_4.1, it can be observed that most of the students' observation skill was in beginning stage with regard to observation of fine details of given specimens, observation of similarities differences between similar pictures, and observation of colour smell appearance texture of chemicals. Also, Students did not employ all the sensory organs, microscope, and magnifying lens skilfully. The students overall performance of observation skill is shown in graph_4.1.

Graph_4.1

Overall Performance of Students in Observation Skill



From the graph 4.1, it can be observed that

- 67.85% students' observational skill was in beginning stage wherein students could not observe the similarities and differences between the two similar pictures (Picture_4.1). Students were unable to observe the morphological characteristics of given specimens such as decayed bread, plants and animal. They could not notice the smell, texture and appearance of chemicals. It indicates that Students did not use magnifying lens, microscope and sense organs skilfully during observations.
- 18.79% students' observational skill was in developing stage wherein very few similarities and differences between similar pictures were observed, very few morphological characteristics of plants and animals was observed, some of the chemicals colour, smell, appearances was correctly noticed. This indicates that students somewhat skilfully used the sense organs, magnifying lens and microscope during observations. However most of the similarities and differences, fine details of specimens, colour, texture, and appearance of chemicals could not observe.

- ❑ 4.91% of students' observational skill was in accomplished stage wherein most of the morphological characteristics of plants and animals were observed; most of fine details of experiment were noticed. But few similarities and differences, fine details could not observe.
- ❑ 8.25% students' observational skill was in proficient stage wherein students correctly observed all the similarities and differences between similar pictures. They observed most of the fine details and morphological characteristics of given specimens such as plants and animal, decayed bread. Students correctly observed the colour, texture, appearance, and smell of the chemicals.

From the above observation, it can be seen that most of the students' observation skill was in beginning stage. This indicates that students did not employ the sense organs, magnifying lens and microscope skilfully.

Picture_4.1: Observation Skill

No	Similarities	Differences
1	It having vacule	not having vacule
2	it having mitochondria	It having mitochondria
3	it having nuclaes	it having nucleus.

3. See the flame of lighted candle. Observe carefully and write any four observations in the tabular column.

No	Observations
1.	the flame colour is down blue and up
2.	it having small flame.
3.	The air will be come the flame
4.	is fall highly.

Table_4.2

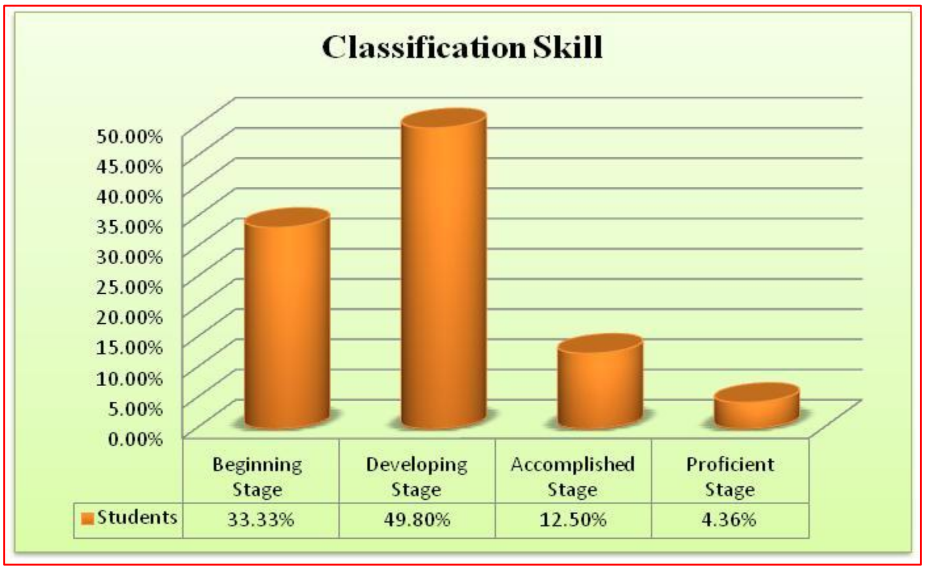
Performance of Students in Classification Skill

Item No	Parameters of Classification Skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplished Stage	% of Students in Proficient Stage
1	Classify into conductors and insulators	(04) 14.28%	(17) 60.71%	(06) 21.42%	(01) 3.57%
2	Classify into magnetic and non magnetic substances	(01) 3.57%	(14) 50%	(10) 35.71%	(03) 10.71%
3	Classify animals based on common attributes.	(24) 85.71%	(03) 10.71%	(01) 3.51%	-
4	Classify into solids liquids and gases.	(08) 28.57%	(20) 71.42%	-	-
5	Classify into pure, impure, opaque, and transparent substances.	(17) 60.71%	(10) 35.71%	(01) 3.57%	-
6	Classify into metals and non metals	(02) 7.14%	(18) 64.28%	(05) 17.85%	(03) 10.71%
7	Classify into hydrophytes, mesophytes& xerophytes.	(08) 28.57%	(24) 50%	(05) 17.85%	(01)3.57%
8	Classify into aerial, arboreal and cave animals.	(13) 46.42%	(12) 42.85%	(01) 3.57%	(02) 7.14%
9	Classify into transparent, translucent and opaque materials.	(07) 25%	(13) 46.42%	(05) 17.85%	(03) 10.71%
10	Classify into herbivores, carnivores and omnivores animals	(20) 71.42%	(08) 28.57%	-	-
11	Classify into soluble, insoluble and slightly soluble substances.	(13) 46.42%	(15) 53.57%	-	-
12	Classify into unicellular and multicellular organisms.	(12) 14.28%	(20) 71.42%	(03) 10.71%	(01) 3.57%
13	Classify into reptiles and amphibians.	(04) 14.28%	(24) 50%	(05) 17.85%	(05) 17.85%
14	Classify into vertebrates and invertebrates.	(06) 21.42%	(15) 53.57%	(06) 21.42%	(01) 3.57%
15	Classify into acids and bases.	(05) 17.85%	(17) 60.71%	(06) 21.42%	-
16	Classify into first order, second order and third order levers	(13) 46.42%	(15) 53.52%	-	-
17	Classify into food materials into pulses and cereals	(10) 35.71%	(14) 50%	(04) 14.28%	-
18	Classify the fruits into dry and fleshy fruits	(09) 32.14%	(12) 42.85%	(05) 17.85%	(02) 7.14%
	Overall Performance	33.33%	49.80%	12.50%	4.36%

From the table_4.2, it can be observed that most of the students' classification skill was in developing stage wherein students correctly classified few of the things, materials, substances, organisms based on similarities and differences. For e.g. 60.71% students correctly classified few conductors and insulators. Similarly, 71.42% of students' classified few things substances into solids liquids and gases. 60.71% students classified very few acids and bases. However they could not classify all the things, materials, substances, organisms based on similarities and differences. The following graph_4.2 shows students overall performance in classification skill.

Graph_4.2

Overall Performance of Students in Classification Skill



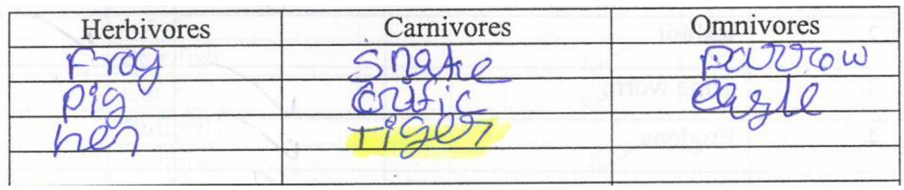
From the graph 4.2, it can be observed that

- 33.33% students classification skill was in beginning stage wherein students could not correctly classify the objects, materials, organisms, substances, fruits based on presence or absence of some common properties, characteristics, and similarities and differences (Picture_4.2).
- 49.89% students' classification skill was in developing stage wherein very few objects, substances, materials, organisms, seeds and fruits were correctly classified based on similarities and differences, however most of the things, substances, and organisms were incorrectly classified.

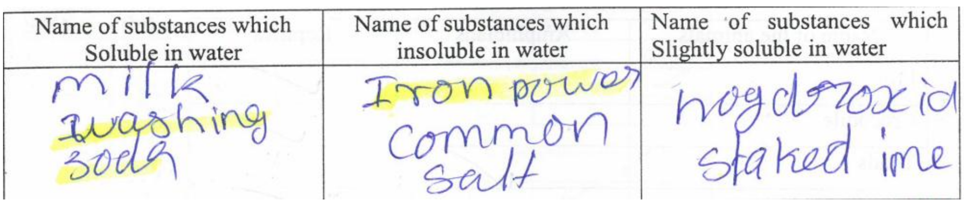
- 12.50% students' classification was in accomplished stage wherein students correctly classified most of the objects, substances, materials, organisms, seeds and fruits based on similarities and differences, presence and absence of certain properties, and characteristics, however few of the objects, substances, materials, organisms, seeds and fruits could not classify correctly.
- 4.36% students' classification skill was in proficient stage wherein all the objects, substances, materials, organisms, seeds and fruits were correctly classified based on the similarities and differences.

From the above observations, it can be inferred that most of the students' classification skill was in developing and beginning stage; very less students were proficient in classification skill.

Picture_4.2: Classification Skill



Herbivores	Carnivores	Omnivores
Frog	snake	parrow
pig	crific	eagle
hen	tiger	



Name of substances which Soluble in water	Name of substances which insoluble in water	Name of substances which Slightly soluble in water
milk washing soda	Iron power common salt	hogdroxid staked ime

Table_4.3

Performance of Students in Communication Skill

Item No	Parameters of Communication Skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplis hed Stage	% of Students in Proficient Stage
1.	Draw a line graph for velocity versus time	(09) 32.14%	(18) 64.28%	-	(01) 3.57%
2.	Draw a bar graph for data on requirements of calorific value for adults with respect to their age	(18) 64.28%	(07) 25%	(02) 7.14%	(01) 3.51%
3.	Name of the different electric component corresponding to the symbols	(24) 85.71%	(04) 14.28%	-	-
4.	Draw arrow mark to show flow of energy between different organisms.	(01) 3.58%	(07) 25%	(10) 35.71%	(10) 35.71%
5.	Draw the arrow mark to show the food web among the different organisms.	-	(06) 21.42%	(24) 50%	(08) 28.57%
6.	Draw line graph for uniform speed verses time.	(07) 25%	(21) 75%	-	-
7.	Draw line graph for non uniform speed verses time.	(07) 25%	(21) 75%	-	-
8.	Write name of elements corresponding to symbols in picture	(16) 57.14%	(11) 39.28%	(01) 3.57%	-
9.	Draw pie chart to show percentage of atmospheric gases.	(05) 17.85%	(11) 39.28%	(07) 25%	(05) 17.85%
10.	Draw the diagram of Human heart.	(06) 21.42%	(15) 53.57%	(06) 21.42%	(01) 3.57%
11.	Write name of the elements corresponding to symbol.	(27) 96%	-	(01) 3.57%	-
12.	Draw the diagram of Human brain.	(15) 53.57%	(11) 39.28%	-	(02) 7.14%
13.	Write different stages of metamorphosis of insects.	(17) 60.71%	(07) 25%	(03) 10.71%	(01) 3.57%
14.	Draw the tabular column to show life span of different organisms.	(06) 21.42%	(04) 14.28%	(10) 35.71%	(08) 28.57%
15.	Write chemical formula for chemical reaction.	(26) 92.85%	(01)3 .57%	(01) 3.57%	-
16	Write steps of tissue culture technique.	(07) 25%	(16) 57.14%	(02) 7.14%	(03) 10.71%
Overall Performance		42.63%	35.71%	12.72%	8.92%

From the table_4.3, it can be seen that most of the students' communication skill was in beginning stage wherein they could not communicate effectively through line graph, pie chart, bar diagram and tables for the given data. It can be observed from the table that 85.71% students' could not communicate through symbol of electric components. Similarly 96% students could not communicate through elements symbols. Very few students' communication skill was accomplished and proficient stage. Students overall performance in communication skill is shown in the graph_4.3.

Graph_4.3

Overall Performance of Students in Communication Skill

It can be observed from the graph 4.3 that

- 42.63% students' communication skill was in beginning stage wherein student unable to communicate through line graph, and bar diagram for the given data. Students incorrectly drew the line graph, did not write title, X axis and Y axis; similarly, drew incorrect pie chart for the given data (Picture_4.3). Also they could not write symbols for chemical elements such as Oxygen, Carbon and Nitrogen. They could not draw tabular column and display the complete data.
- 35.71% students' communication skill was in developing stage wherein correctly communicated through graph, pie chart, and symbols to some extent. They wrote X axis and Y axis but plotted line graph and bar diagram was incorrect and incomplete. Few chemical elements names and electrical components names corresponding to the symbols written correctly. They could not communicate effectively through tabular column.

- 12.72% students' communication skill was in accomplished stage wherein students to some extent effectively communicated through line graph, bar graph, diagram, tables, pie chart and line graph, however they committed some error.
- 8.92% students' communication skill was proficient stage wherein students' very proficient in plotting line graph, bar graph, tabular column. They skilfully drew the diagram and written the symbols; also they effectively communicated through electric components.

From the graph 4.3, it can be inferred that most of the students' communication skill was beginning stage and developing stage; very less students were in accomplished and proficient stages.

Picture_4.3: Communication Skill

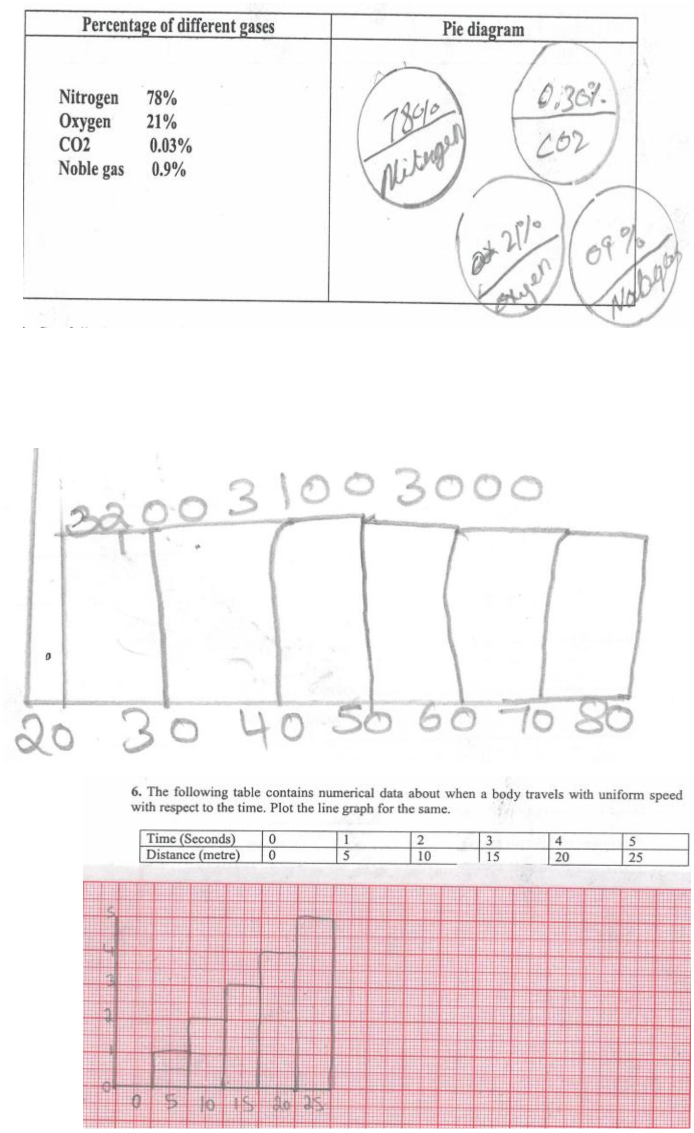
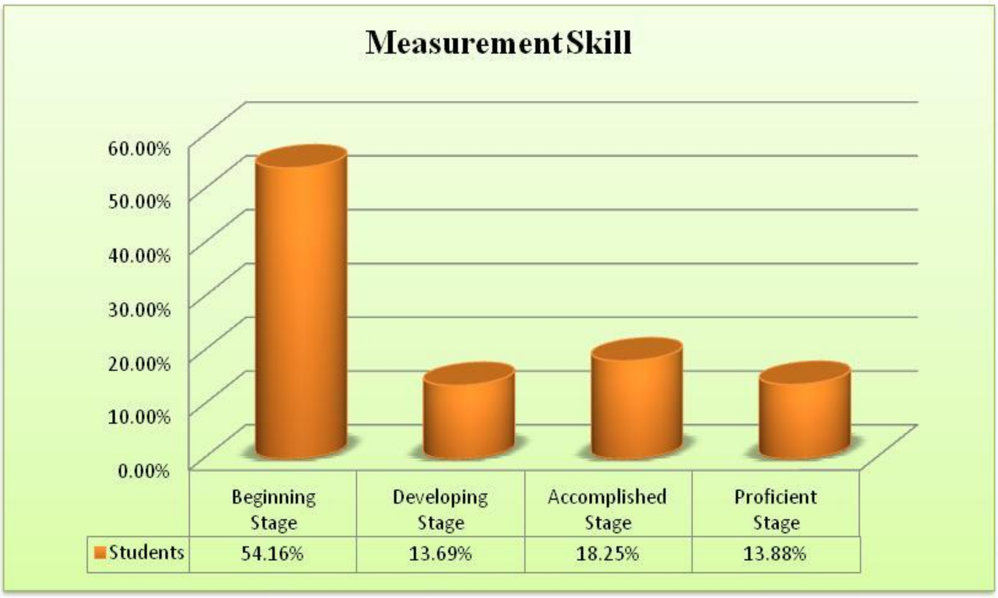


Table_4.4
Performance of Students in Measurement Skill

Item No	Parameters of Measurement Skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accompli-Shed Stage	% of Students in Proficient Stage
1	Measure the length, breadth of rectangle diagram.	(03) 10.71%	(06) 21.42%	(13) 46.42%	(06) 21.42%
2	Measure the base and height of the triangle diagram	(09) 32.14%	(10) 35.71%	(07) 25%	(02) 7.14%
3	Measurement of exact amount of water in measuring cylinder.	(12) 42.85%	(08) 28.57%	(06) 21.42%	(02) 7.14%
4	Measure the length, breadth and height of the cuboids diagram.	(08) 28.57%	(04) 14.28%	(09) 32.14%	(07) 25%
5.	Measure the angles between two joined lines of the diagram.	(15) 53.57%	(01) 3.57%	(06) 21.42%	(06) 21.42%
6.	Measure the total area of leaf.	(20) 71.42%	(04) 14.28%	(03) 10.71%	(01) 3.57%
7.	Measure the mass of the object using pointer balance.	(19) 67.85%	(05) 17.85%	-	(04) 14.28%
8.	Measure the temperature of hot water.	(11) 96.42%	-	(01) 3.57%	-
9.	Measure the length, breadth and height of the table	(17) 60.71%	(02) 7.14	(04) 14.28%	(05) 17.85%
10.	Determine the volume of irregular object (Stone) by displacement of water	(25) 89.28%	(01) 3.57%	(02) 7.14%	-
11.	Measure the length of the pendulum and time period of oscillations.	(19) 67.85%	(01) 3.57%	(03) 10.71%	(05) 17.85%
12.	Measure the length and breadth of cloth.	(19) 67.85%	(02) 7.14%	(05) 17.85%	(02) 7.14%
13.	Measuring $KMnO_4$solution in graduated beaker.	(08) 28.57%	(05) 17.85%	(13) 46.42%	(02) 7.14%
14.	Pipette out 20 ml of water from beaker.	(11) 39.28%	(08) 28.57%	(06) 21.42%	(03) 10.71%
15.	Measure the thickness of book& calculate thickness of one page.	(25) 85.71%	(01) 3.51%	(03) 10.71%	-
16.	Measuring the temperature of classroom in Celsius and Fahrenheit scale.	(27) 96.42%	-	(01) 3.57%	-
17.	Measure the Length of curved line diagram.	(08) 28.57%	(05) 17.85%	(08) 28.57%	(07) 25%
18.	Measure the length and breadth of post card	(02) 7.14%	(06) 21.42%	(02) 7.14%	(18) 64.28%
Overall Performance		54.16%	13.69%	18.25%	13.88%

From the table_4.4, it can be observed that most of the students' measurement skill was in beginning stage wherein students could not measure the length, breadth, height, temperature, weight, area and volume of liquids correctly. Students overall performance in measurement skill is shown in the graph_4.4.

Graph_4.4
Overall Performance of Students in Measurement Skill



From the graph 4.4, following observations can be made

- 54.16% students' measurement skill was in beginning stage wherein students incorrectly measured the length, breadth, width, weight, temperature, volume of water and volume of irregular objects with the help of measurement devices. For example, length of simple pendulum, thickness of one page measured incorrectly (Plate_4.1). Similarly, students unable to used pipette and burette skilfully while measuring the volume of water.
- 13.69% students' measurement skill was in developing stage wherein students to some extent correctly followed measurement procedure while measuring the length, breadth, volume, weight, time, temperature. However the measurement was inaccurate because they committed some sort of measurement error. Hence, the measurement was slightly less or slightly more than the accurate and precise.
- 18.25% students' measurement skill was in accomplished stage wherein students correctly followed the measurement procedure while measuring the object or liquids but they committed minute error. For example, while

measuring the volume of liquids, students could not observe lower or higher meniscus. Similarly, while measuring the total area of irregular object (stone), and to find out the volume of irregular object (stone) students almost followed correct measurement procedure, however the measurement was not imprecise and inaccurate.

- 13.88% students' measurement skill was proficient stage wherein students followed correct measurement procedure, also very accurately measured the length, breadth, temperature, angle, weight, volume, total area of irregular object (leaf) with the help of appropriate measurement devices such as scale protractor pipette burette measurement tape etc. Also, written with correct measurement units.

It can be inferred from the above observations that most of the students' measurement skill was in beginning stage; however few students were in accomplished stage.

Plate_4.1: Measurement Skill

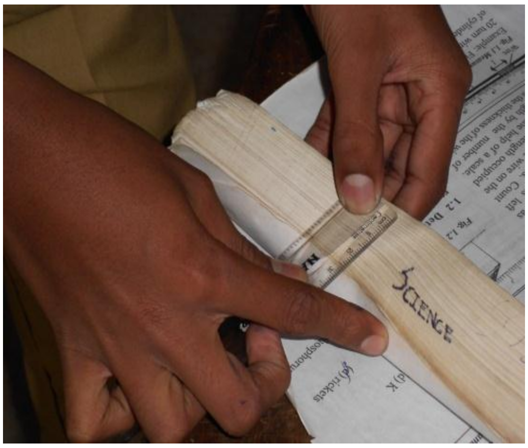
Measuring the length of Simple Pendulum	*Find out the thickness of book and thickness of one page*
	

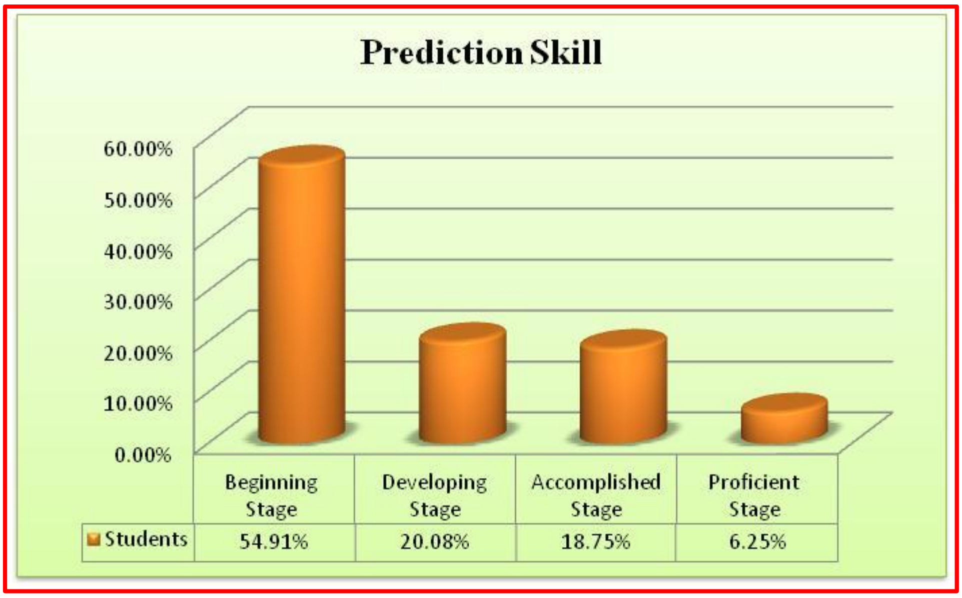
Table_4.5
Performance of Students in Prediction Skill

Item No	Parameters of Prediction Skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplished Stage	% of Students in Proficient Stage
1.	Predict:(a) ice cubes float or sink in water. (b) Change of water level.	(23) 82.14%	(03) 10.71%	(02) 7.14%	-
2.	Predict: time taken for number of oscillations at different length.	(19) 67.85%	(05) 17.85%	(04) 14.28%	-
3.	Predict: floatation of different liquids having different densities.	(08) 28.57%	(07) 25%	(09) 32.14%	(04) 14.28%
4.	Predict: Egg will float or sink in(i) water, (ii) salt solution and (iii) vinegar.	(10) 35.71%	(06) 21.42%	(12) 42.85%	-
5.	Predict the angle between two joined plane mirrors.	(22) 78.57%	(06) 21.42%	-	-
6	Predict: floating or sinking of vegetable/substances in water and kerosene.	(08) 28.57%	(16) 57.14%	(04) 14.28%	-
7.	Predict: temp of hot water and cold water.	(20) 71.42%	-	(08) 28.57%	-
8.	Predict: first dissolving substances in water.	(20) 71.42%	(01) 3.57%	(05) 17.85%	(02) 7.14%
9.	Predict: miscibility and immiscibility of liquids in water	(04) 14.28	(11) 39.28	(09) 32.14	(04) 14.28
10.	Predict: osmosis (thistle funnel experiment).	(17) 60.71%	(06) 21.42%	(04) 14.28%	(01) 3.57%
11.	Predict: seed germination faster in soil + fertilizer or soil + manure.	(21) 75%	(01) 3.57%	(04) 14.28%	(02) 7.14%
12.	Predict: melting of ice faster in cold water or Salt solution or Sugar solution.	(22) 78.57%	(02) 7.14%	(03) 10.71%	(01) 3.57%
13.	Predict: temperature of water decrease faster in which vessel.	(10) 35.71%	(14) 50 %	-	(04) 14.28%
14.	Predict: evaporation faster in petrol or water.	(20) 71.42%	(02) 7.14%	(06) 21.42%	-
15.	Predict about rain	(05) 17.85%	(02) 7.14%	(13) 46.42%	(08) 28.57%
16.	Predict about a leaf with worm.	(17) 60.71%	(08) 28.57 %	(01) 3.57%	(02) 7.14%
Overall Performance		54.91%	20.08%	18.75%	6.25%

From the table_4.5, it can be observed that most of the students' prediction skill was in beginning stage wherein students could not correctly predict the events and occurrences based on observation and experiences. Thier prediction was incorrect and given reason for prediction also incorrect. The following graph_4.5 shows students overall performance in prediction skill.

Graph_4.5

Overall Performance of Students in Prediction Skill



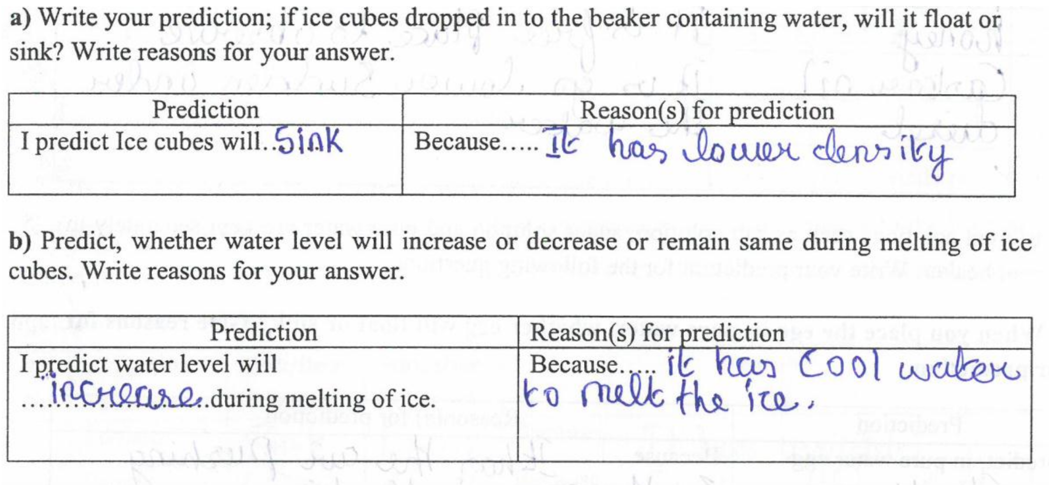
It can be observed from the graph 4.5 that

- ❑ 54.91% students' prediction skill was in beginning stage wherein students incorrectly predicted the events and occurrences based on observation of experiments and previous experiences. For example, Students prediction was incorrect with regard to floating and sinking of ice cubes in water. They predicted that ice cubes sinks in water (Picture_4.4), also they could not correctly predicted the time period for simple pendulum oscillations. Similarly, predicted angle between two joined plane mirrors was incorrect.
- ❑ 20.08% students' prediction skill was in developing stage wherein students' prediction was correct but the given reason for prediction was incorrect and irrelevant. For example students correctly predicted that ice float in water but unable to write reasons for prediction.
- ❑ 18.75% students' prediction skill was in accomplished stage wherein students' correctly predicted based on observation but written reasons for prediction was partially correct, not completely correct. For example, students correctly predicted that seed germinates faster in soil with fertilisers but given reason was not completely correct.

- 6.25% students' prediction skill was in proficient stage wherein students correctly predicted the future occurrences and events based on prior observations and experiences and given correct reasons for the prediction. They correctly predicted with regard to floating and sinking, miscibility and immiscibility of liquids and written correct reasons, seed germination.

From the above observations it can be inferred that most of the students' prediction skill was in beginning stage. Very less students' prediction skill was in proficient stage.

Picture_4.4: Prediction Skill



a) Write your prediction; if ice cubes dropped in to the beaker containing water, will it float or sink? Write reasons for your answer.

Prediction	Reason(s) for prediction
I predict Ice cubes will..Sink	Because..... It has lower density

b) Predict, whether water level will increase or decrease or remain same during melting of ice cubes. Write reasons for your answer.

Prediction	Reason(s) for prediction
I predict water level will ....increase..during melting of ice.	Because..... it has cool water to melt the ice.

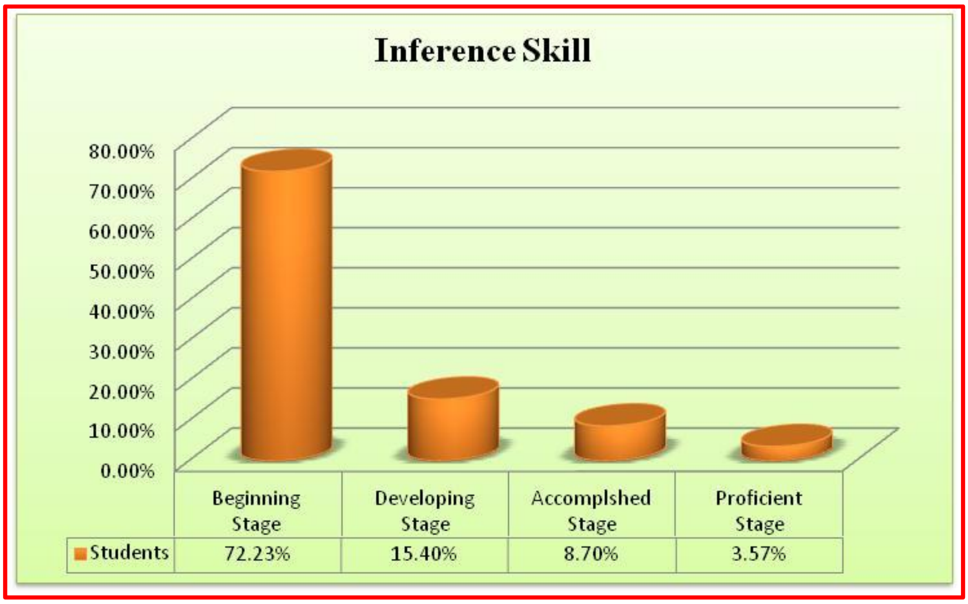
Table_4.6
Performance of Students in Inference Skill

Item No	Parameters of Inference skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplished Stage	% of Students in Proficient Stage
1.	Inference based on observation of melting of ice cubes in thistle funnel with thermometer.	(17) 60.71%	(05) 17.85%	(05) 17.85%	(01) 3.57%
2.	Inference based on observation of photosynthesis picture.	(22) 78.57%	(05) 17.85%	-	(01) 3.57%
3.	Inference on Soluble and insoluble substances in water.	(19) 67.85%	(06) 21.42%	(01) 3.57%	(02) 7.14%
4.	Inference based on observation of acid and base test.	(25) 89.28	(03) 10.71	-	-
5.	Inference on transfer of heat in solid (iron rod experiment)	(18) 64.28%	(04) 14.28%	(03) 10.71%	(03) 10.71%
6.	Inference on solar eclipse and lunar eclipse	(13) 46.42%	(07) 25%	(03) 10.71%	(05) 17.85%
7.	Inference on observation of transpiration picture	(22) 78.57%	(03) 10.71%	(03) 10.71%	-
8.	Inference based on floatation of different liquids in water.	(25) 89.28%	(02) 7.14%	-	(01) 3.57%
9.	Inference based on absorption of heat by empty inflated balloon, &absorption of heat by inflated balloon with water when brought over the lighted candle.	(15) 53.57%	(05) 17.85%	(07) 25%	(01) 3.57%
10.	Inference based on Simple pendulum experiment.	(22) 78.57%	(04) 14.28%	(02) 7.14%	-
11.	Inference based on observations of water droplets on outer surface of the steel tumbler.	(17) 60.71%	(08) 28.57%	(02) 7.14%	(01) 3.57%
12.	Inference based on observation of experiment on neutralisation of acid base test.	(24) 85.71%	(03) 10.71%	(01) 3.57%	-
13.	Inference based on change of states of matter (Melting, Sublimation and Vaporisation)	(25) 89.28%	(01) 3.57%	(02) 7.14%	-
14.	Inference on anomalous expansion of water in pond	(25) 89.28%	(02) 7.14%	(01) 3.57%	-
15.	Inference on food Chain between different organisms	(09) 32.14%	(09) 32.14%	(09) 32.14%	(01) 3.57%
16.	Inference on different types of levers	(26) 92.85%	(02) 7.14%	-	-
Overall Performance		72.23%	15.40%	8.70%	5.57%

From the table_4.6, it can be seen that most of the students' inference skill was in beginning stage where they could not derive inferences based on observation of pictures, experiments and videos. Instead, they wrote observations. 92.85% students did not derive inferences on types of levers. Similarly, 89.28% students could not derive inferences on change of states of matter. The following graph_4.6 shows students overall performance in inferences skills.

Graph_4.6

Overall Performance of Students in Inference Skill



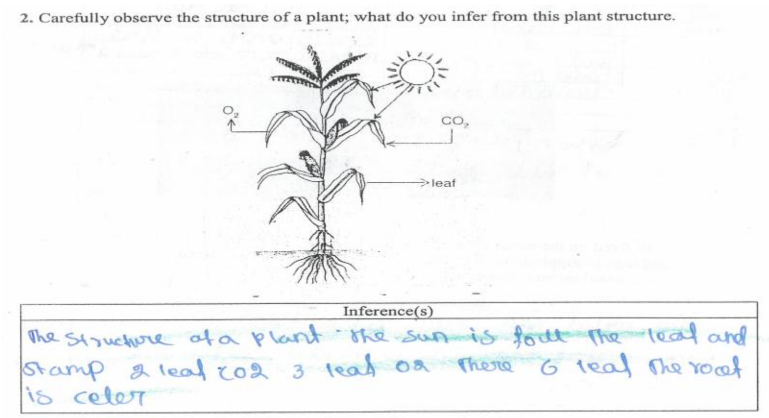
The following observations can be derived from the graph 4.6.

- ❑ 72.23% students' inference skill was in beginning stage wherein students could not derive any inferences based on observations of picture, experiment, demonstration and videos, instead they wrote observations (Picture_4.5). Also students unable to differentiate between observation and inferences.
- ❑ 15.40% students' inference skill was in developing stage wherein students' derived very few inference(s) correctly based on observations of picture, experiment, demonstration and videos. However they wrote more observations from the pictures and experiments.
- ❑ 8.70% students' inference skill was in accomplished stage wherein students derived most of the inference(s) correctly based on observations of experiment and pictures. However few inference(s) not derived, instead students written few observations.

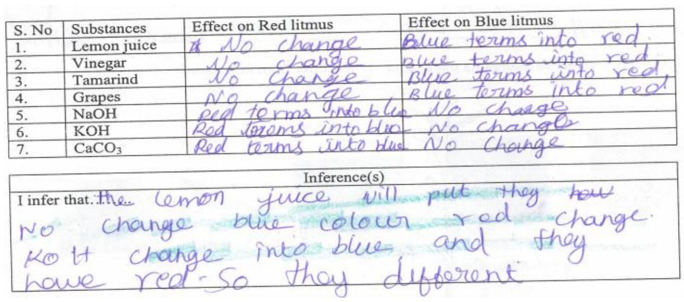
- 3.57% students' inference skill was in proficient stage wherein students derived inferences correctly and completely based on observation of picture experiments videos. Also Students able to differentiate between observations and inferences.

From the above observations, it can be inferred that most of the students' observation skill was beginning stage; very less students proficiency in inference skill.

Picture_4.5: Inference Skill

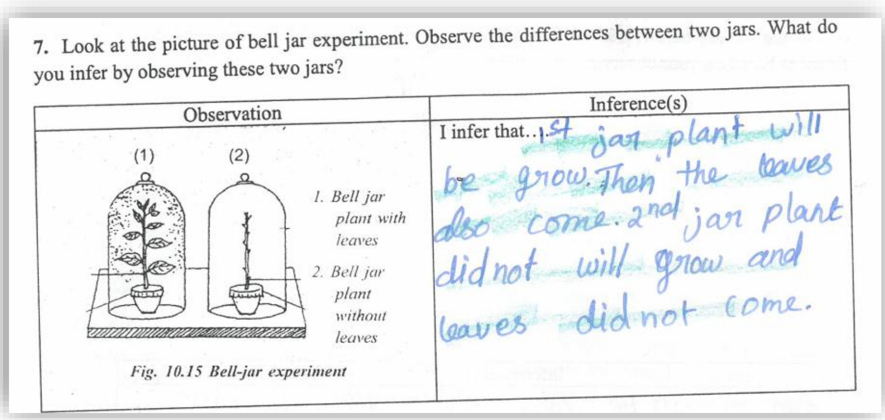

2. Carefully observe the structure of a plant; what do you infer from this plant structure.

Inference(s)
The structure of a plant the sun is fall the leaf and stamp 2 leaf co2 3 leaf o2 there 6 leaf the root is celer



S. No	Substances	Effect on Red litmus	Effect on Blue litmus
1.	Lemon juice	No change	Blue terms into red
2.	Vinegar	No change	blue terms into red
3.	Tamarind	No change	Blue terms into red
4.	Grapes	No change	Blue terms into red
5.	NaOH	Red terms into blue	No change
6.	KOH	Red terms into blue	No change
7.	$CaCO_3$	Red terms into blue	No Change

Inference(s)
I infer that the lemon juice will put they how no change blue colour red change. KOH change into blue and they have red. So they different


7. Look at the picture of bell jar experiment. Observe the differences between two jars. What do you infer by observing these two jars?

Observation	Inference(s)
(1) (2) 1. Bell jar plant with leaves 2. Bell jar plant without leaves *Fig. 10.15 Bell-jar experiment*	I infer that 1st jar plant will be grow. Then the leaves also come. 2nd jar plant did not will grow and leaves did not come.

Table_4.7

Outline of Implementation of Experiential Learning Intervention Programme for Developing BSPS

Date	Contents Chosen to Develop Process Skills	Learning Objectives	Learning Experience followed Kolb's EL Cycle	Skills Expected to Acquire
22.08.11	Agricultural Practices. ▪ Manual Ploughing ▪ Tractor Ploughing ▪ Levelling of Soil ▪ Sowing of seeds by manually and by Machine.	To develop the skill observation, classification, communication and inference.	Multimedia Presentation	❑ Observe the difference between manual and machine ploughing. ❑ Observe the difference between machine and manual sowing of seeds. ❑ Observe and classify the seeds based on the similarities and differences. ❑ Draw the flow chart, taking notes, drawing diagrams. ❑ Derive inference on purpose of ploughing, levelling and sowing.
23.04.11	Different types of Irrigation ▪ (Furrow irrigation, basin irrigation, Sprinkler irrigation and Drip irrigation). Methods of Weeding. Harvesting Threshing and winnowing. Storage of seeds	To develop the skill of Observation classification communication and inference.	Multimedia Presentation	❑ Identify the similarities and differences in different types of irrigation. ❑ Observe the manual method weeding, and different types of weedicides. ❑ Observe the manual and machine harvesting of paddy. ❑ Classify the weedicides and fertilizers. ❑ Classify the fruits into cold storage and dry storage. ❑ Classify the crops into cereals, vegetable, grains, pulses ❑ Acquiring the skill of drawing, making tabular column. ❑ Derive inference on irrigation, weeding, harvesting, threshing and winnowing.

24.04.11	Observation of bean plant	To develop the skill of observation communication and Inference.	Hands on Experiences	❑ Observe the bean plant root and leaves. ❑ Draw the diagrams of leaf and root of bean plant. Communicate with others using scientific terms. ❑ Infer the function of root nodules**.**
26.08.11	Physical changes between boys and girls during puberty. Endocrine glands: ▪ Pituitary and thyroid ▪ Pancreas ▪ Adrenal an ▪ Testes and Ovaries	To develop the skill of observation and inference. To develop the skill of observation, communication and inference.	Multimedia Presentation Multimedia Presentation	❑ Observe the physical changes takes place among boys and girls during adolescent. ❑ Infer that what are the changes takes place at the stage of puberty for boys and girls ❑ Observe the location of different glands such as Pituitary, Thyroid, Pancreas, Adrenal, and Testes and Ovaries. ❑ Infer that where these glands are secreted and how it passed to other parts of body; also infer that functions of glands and deficiency syndrome.
29.08.11	Chromosome and Sex Determination Smoking Hazards Cancer and its classification	To develop the skill of observation classification prediction and inference. To develop the skill of observation, and inference. To develop the skill of observation, classification, communication inference.	Multimedia Presentation Multimedia Presentation Multimedia Presentation	❑ Observe the shape and structure of human egg, sperm, and chromosome. ❑ Classifying body chromosome and sex chromosome. ❑ Predict the chromosome responsible to determine the sex. ❑ Communicate with others by drawing the diagram. ❑ Make Inferences. ❑ Observe the hazards of smoking in human organs such as mouth cancer, blockage of nerve cells, constriction of blood vessels, lining of arteries. ❑ Inference that how smoking affects Human internal organs. ❑ Observe the different types of cancers and its effects. ❑ Classify different types cancers ❑ Communicate with others effectively using scientific terms. ❑ Inference that causes, types, and symptoms of cancers.

30.08.11	Sprouting of seeds	To develop the skills observation communication and inference.	Hands on Experience	❑ Observe the sprouted seeds colour, shape, number of cotyledons. ❑ Draw the seeds diagrams and Communicate with others. ❑ Infer that the process of seed germination.
02.09.11	Human Skeleton ▪ Types of joint ▪ Different types of bones	To develop the skill of observation communication and inference.	Multimedia Presentation	❑ Observe the human skeleton system, joints and different bones. ❑ Draw the entire skeleton system, and bones and joints. ❑ Interact with other students to develop the verbal communication. ❑ Infer the functions of Human bones.
05.09.11	Human skeleton	To develop the skill of observation and communication.	Hands on Experience in laboratory.	❑ Observe and touch the bones of Human skeleton. ❑ Observe the skull, shoulder bone, rips, spine, hip bone and thigh bone. and count the number of bones in rips. ❑ Drawing the human skeleton and label the parts. ❑ Communicate with others.
06.09.11	▪ Fish and it movements. ▪ Earthworm and its movements. ▪ Cockroach and its movement.	To develop the skill of observation, communication, and inference	Hands on experience	❑ Observed the fish shape and its movement. ❑ Observe the body of earthworm, segments, and different parts, and its movements. ❑ Observe the structure of cockroach, its body parts fine details, its movement. ❑ Make inferences on earthworm and cockroach.
08.09.11	▪ Various Types of irrigation ▪ Fungi observation	To enhance the skills of observation, communication and inference. To develop Observation, communication and inference skill.	Simulation Models Hands on Experience	❑ Observe the canal irrigation, furrow irrigation, drip irrigation and basin irrigation and their major difference between them. ❑ Discuss, Draw the different types of irrigation ❑ Infer that different types of crops require different types of irrigation. ❑ Observe the smell, colour and fine details of fungi. ❑ Draw the structure of fungi and communicate with others. ❑ Derive inferences on fungi.

12.09.11	Difference between dicot and monocot plants	To develop the skill Observation, classification, communication and inference.	Field Visit	❑ Observe the morphological characteristics dicot and monocot of roots, leaves and flowers. ❑ Classify the plants into dicots and monocots. ❑ Based on observations, derive inferences.
13.09.11	Bryophytes and its Classification	To develop the skill of observation, classification, communication and inference.	Multimedia Presentation	❑ Observe root like, stem like leaf like structures of bryophytes ❑ Classify the bryophytes based on their presence and absence of certain features. ❑ Draw the structure of bryophytes and discuss with others, make inferences.
14.09.11	Algae and its Classification	To develop the skill of observation, classification, communication and inference.	Multimedia Presentation	❑ Observe the different types of algae and its morphological structures. ❑ Classify the algae into different types based on presence and absence of pigments. Discuss with others for developing communication. ❑ Derive inferences on algae.
13.09.11	Earthworm structure and its movement	To develop the skill observation, communication and inference.	Hands on experience	❑ Observe the earthworm body structure and its nature, movements. ❑ Draw the earthworm structure and discuss with others. ❑ Derive inferences.
15.09.11	Anatomy of dicot Root	To develop the skill of observation, communication, and inference.	Hands on experience	❑ Observe the arrangement of different types of cells in dicot root through microscope. ❑ Draw the structure of dicot roots and label it properly. ❑ Discuss with students about their observations, and derive Inference.
16.09.11	Anatomy of dicot stem. Anatomy of dicot leaf	To develop the skill of observation, communication, and inference. To develop the skill of	Hands on experience	❑ Observe the arrangement of different types of cells in dicot stem in microscope. ❑ Draw the structure of dicot stem and label it properly. ❑ Discuss with other students about their observations, and derive inferences.

		observation, communication, and inference.	Hands on experience	❑ Observe the arrangement of different types of cells in dicot leaf through microscope. ❑ Draw the structure of dicot leaf and label it properly. ❑ Discuss with other students about their observations, and derive inferences.
17.09.11	Effects of Tobacco	To develop observation, communication and inference skills.	Group Presentation	❑ Observe the picture of lungs and heart which are affected by tobacco. ❑ Draw diagram and communicated with other students, and make inferences.
19.09.11	Observation of Monocotyledons and dicotyledons seeds	To develop the skill of observation, classification, communication and inference.	Hands on Experience	❑ Observe the differences between monocotyledons and dicotyledons seeds. ❑ Classify the given seeds such as paddy, maize, wheat, bean, pea, mango into monocots and dicots based on similarities and differences. ❑ Discus with others, and drawing the diagram of monocotyledons and dicotyledons, and derive inferences.
20.09.11	Morphological Characteristics of Monocot and Dicot Plants	To develop the skills of observation, classification, communication and inference.	Field Visit	❑ Observe the leaf, root, flower of monocot plants and dicot plants. ❑ Make out the similarities and differences between them. ❑ Classify the list of observed plants into monocots and dicots. ❑ Discuss with others and draw the diagram of the same. ❑ Make inference based on the observations of morphological characteristics of leaf, flower and root that monocotyledons are differing from dicots.
10.10.11	Micro organisms: Virus, Bacteria, Algae.	To develop the skill of observation, classification, inference.	Multimedia Presentation	❑ Observe the shape and structures of micro organisms such as bacteria, virus and Chlamydomonas. ❑ Derive inference with regard to bacteria, fungi and Chlamydomonas.

11.10.11	Fermentation	To develop the skill of observation prediction and inference.	Hands on Experience	❑ Observe the materials required for doing experiments, and procedure of doing experiments. ❑ Predict what will happen in terms of colour, smell, quantity etc. ❑ After sometimes observe the smell and colour of sugar solution. ❑ Derive inference on fermentation.
13.10.11	▪ Observation of root nodules of leguminacious plant. ▪ Observation of infected citrus canker Leaf. ▪ Observation of bread Mould	To develop the skills of observation, communication inference. To develop the skill of observation, communication, prediction and inference. To develop the skill of observation communication and inference.	Hands on Experience Hands on Experience Hands on experience	❑ Observe the primary, secondary and tertiary roots; and root nodules of leguminacious plants (Bean Plant). ❑ Communicate with others and draw the structure of roots. ❑ Infer that root nodules helps for nitrogen fixation in the soil. ❑ Observe the infected citrus canker leaf. ❑ Communicate with others and draw the leaf. ❑ Predict that what is going to happen of the entire leaf after two or three days. Based on the observations derive inferences. ❑ Observe the colour, smell, and appearance of bread mould. ❑ Communicate with others orally, and draw the structure of the same. ❑ Derive inferences.
24.10.11	Bacteria Binary Fission	To develop the skill of observation, communication and inference.	Multimedia Presentation	❑ Observe the different steps and process of binary fission of bacteria. ❑ Communicate with others and draw the different steps of binary fission, and derive inferences.
25.10.11	Bacteria and its Types	To develop the skill of observation, classification and inference.	Multimedia Presentation	❑ Observe the different types of bacteria, its shapes, and its number of flagella. ❑ Classify the bacteria based on their shape. Classify the bacteria based on the presence of position of number of flagella. ❑ Draw the structure and derive inferences.

27.10.11	Degradable and non-degradable Substances	To develop the skill of observation, classification. Communication, prediction and inference.	Hands on Experience	❑ Observe the different types of materials such as plastics, waste food, fruits, iron, papers etc. ❑ Predict the degradable and non degradable materials. ❑ Classify the given material into degradable and non degradable materials, communicate with others. ❑ Derive inferences on degradable and non degradable..
01.11.11 and 02.11-11	Structure of plant cell and animal cell, and its organelles.	To develop the skill of observation Communication and inference.	Multimedia presentation	❑ Observe the similarities and differences between plant cell and animal cells with respect to their shape, presence and absence of organelles. ❑ Discuss with others and draw the diagram of plant cell and animal cells and their organelles. ❑ Derive inferences.
03.11.11 and 05.11.11	▪ Different types of cells in human body (fat cells, sperm cells, bone cells, blood cells, smooth cells. ▪ Structure of Human eye and kidney.	To develop the skill of observation, communication and inference. To develop the skill of observation and communication.	Multimedia presentation Simulated Models	❑ Observe the shapes of human cells in terms of their shape. ❑ Discuss with other students and draw different types of cells. ❑ Infer that different types of cells perform different functions in our body. ❑ Observe the simulated model of human eye and kidney, and different types of human cells. ❑ Communicate with others using simulated models, and discuss with other students.
08.11.11	▪ How to measure temperature of water, human body using thermometer.	To develop the skill of Observation, measurement and prediction.	Hands on Experience	❑ Predict the temperature of cold water and human body temperature. ❑ Observe the thermometer scale lower limit and upper limit readings and level of mercury. ❑ Measure the temperature of water and human body and write with appropriate its units.

				❑ Observe the raising and lowering of mercury level in the thermometer. ❑ Observe the readings given in the graduated measurement jar.
	▪ How to measure liquids by using Measurement jar.	To develop observation, measurement skills.	Hands on Experience	❑ Measure the given liquids (Water) exactly without lower or upper meniscus. ❑ Observe the accuracy of liquids taken in the jar and write accurately with units.
	▪ Simple pendulum Measurement.	To develop observation, communication, measurement, prediction and inference.	Hands on Experience	❑ Observe the simple pendulum experimental set up. ❑ Measure the length of pendulum accurately from the point of suspension to the centre of bob. ❑ Observe and measure the exact time period for ten oscillations at particular lengths and find out the time taken for one oscillation. ❑ Predict the time taken for ten oscillations if the length of the pendulum is increased. ❑ Verify the prediction by doing experiments repeatedly by increasing length of pendulum and calculate the time taken for one oscillation.
	▪ To measure the length, breadth, height of the object.	To develop the skill of measurement, communication.	Hands on Experience	❑ Draw tabular column and the length of pendulum, no of oscillation, time taken for no of oscillation. ❑ Measure the length, breadth and height of the table using measurement tape. Draw the table to enter the quantified data. ❑ Write measurement with appropriate units.
	▪ To measure the weigh the object using spring balance.	To develop the skill of Measurement.		❑ Measure the weight of given objects accurately using spring balance and write it measurements with proper units.

09.11.11	Find out thickness of one page.	To develop the skill of measurement.	Hands on experience	❑ Measure the thickness of science text book and calculate the thickness of a page.
09.11.11	Measure the volume of irregular Object (Stone).	To develop the skill of observation, measurement and inference.	Hands on experience	❑ Measure the initial level of water in the graduated cylinder and the same note it down. ❑ Immersed the stone into water and noticed/measured the final level of water in the graduated cylinder and the same was recorded. ❑ Find out the volume of stone and derive inferences.
09.11.11	Flow of current in the wire measured by ammeter.	To develop the skill of observation measurement.	Demonstrati on & hands on experience	❑ Observe the needle deflection in the ammeter when the wire connected with battery and ammeter. ❑ Measure that how much current passed over the connected wire by using ammeter.
09.11.11	Measure the temperature of classroom in Celsius and Fahrenheit scale	To develop the skill of observation and measurement	Hands on experience	❑ Measure the temperature of classroom in Celsius and Fahrenheit scale. ❑ Carefully Observe the mercury level in the in Celsius and Fahrenheit scale and the same note it down with units.
09.11.11	Measurement of angle between two lines using protractor	To develop the skill of observation and measurement	Hands on experience	❑ Drawn the two lines (one is vertical and other one horizontal) and measure the angles between two lines and the same written in appropriate units.
09.11.11	Pipette out of water	To develop the skill of observation, measurement.	Hands on experience	❑ Measure 20 ml of water using pipette from graduated beaker. ❑ Observe the water in the pipette to avoid lower and upper meniscus.
10.11.11	Observe the specimens of plants and insects in laboratory	To develop the skill of observation, classification, and inference.	Hands on experience in laboratory	❑ Observe the colour, shape, structure and important characteristics of plants and insect. ❑ Observe the star fish, earthworm, spider, centipede millipede etc ❑ Classify the animals based on similarities and differences. ❑ Make inferences based on inferences.

11.11.11	Percentage of elements on the earth and , percentage of elements in Human body	To develop the skill of observation, communication and inference.	Group activity cum Discussion	❑ Observe the numerical data of percentage of elements in the Earth crust, and percentage of elements present in the Human body. ❑ Draw the pie chart for percentage of elements in the earth crust, and percentage of elements in human body. ❑ Derive inferences based on observations.
11.11.11	Classification of states of matter (Solids, Liquids, and Gas)	To develop the skill of observation, classification, communication and inference.	Hands on experience	❑ Observe the different materials/substances such as scale, pen, pencil, book, carbon, silicon, copper, gold, mercury, water, oil, fuming agarpathi, inflated balloon. ❑ Classify the given materials/substances into solids, liquids and gases based on similarities and differences. ❑ Make inference(s) on states of matters.
11.11.11	Classification Elements	To develop the skill of observation, classification and inference.	Hands on experience	❑ Observe the list of names of materials/substances such as copper, gold, silver, iron, hydrogen, oxygen, sulphur, carbon, boron, silicon and germanium. ❑ Classify them into metals, non metals and metalloid based on similarities and differences. ❑ Make inferences on metals and non metals and its properties..
11.11.11	Elements (Ex: hydrogen and Oxygen)	To develop the skill of Observation communication and inference	Simulation (Simulated Models of H_2 and O_2.	❑ Observe the simulated models of hydrogen atom and oxygen atom, and observe the symbol for the same. ❑ Make inferences on elements.
14.11.11	Name of the elements and its symbols	To develop the skill of Observation, communication and inference.	Group Discussion	❑ Observe the names of elements on the blackboard. ❑ Draw the tabular column and list out the name of different elements and its symbols Example: Boron (B), Carbon (C), Fluorine (F), Hydrogen (H), Iodine (I), Aluminium (Al), Barium (Ba)Bromine (Br) Lithium (Li) etc....and derive inferences.

14.11.11	Pictorial Symbols of Elements	To develop the skill of observation, communication and inference.	Group Discussion	❑ Observe the pictorial symbols of particular element. ❑ Draw elements name and its symbols in pictorial form. ❑ Derive inferences on elements and symbol representation.
14.11.11	Verify the Sugar is a compound	To develop the skill of observation, prediction and inference.	Demonstrat ion	❑ Observe the physical reaction during heating of sugar in the test tube. Make prediction colour change nature of sugar while heating. ❑ Verify the prediction by making experimentation and observe the sugar on heating. Make inferences based on observations.
14.11.11	Observation of flame of candle.	To develop the skill of observation.	Hands on Experience	❑ Observe the candle flame, colour shape smoke etc.
16.11.11	Floating and sinking of egg in water and acetic acid	To develop the skill of Observation, Prediction and Inference.	Hands on experience	❑ Observe the materials/substances kept for sinking and floating experiment and prediction on predict floating or sinking. ❑ Verify the prediction by doing experimentation, and derive inferences.
16.11.11	Molecule of Compound Ex: HCl, H_2O	To develop the skill of Observation, communication inference.	Role Play	❑ Observe the number of hydrogen atom and number of chlorine atom in Hydrogen chloride (HCl) compound. Similarly observe The number of hydrogen atom and number of oxygen atom in one molecule of water (H_2O) during role play. ❑ Observe the symbol for Hydrogen chloride (HCl), and symbol for water (H_2O) compounds by watching the role play. ❑ Derive inferences on what is compound.
16.11.11	Formation of Element and Compound	To develop Observation, Communication and Inference	Role Play	❑ Observe the formation of element or compound .Observe the number of atom in a molecule to form element or compound. ❑ Also observed the symbol of an element and compound. ❑ Classify the elements and compound.. ❑ Make inferences on elements and compound.

17.11.11	Chemical formula for element or compound	To develop the skill of observation, communication and inference	Role Play	❑ Observe the role play to know the Chemical formula for an element or compound. ❑ Observe the number of sodium atom and number of chlorine atom in one molecule of sodium chloride compound and their formula (NaCl). ❑ Similarly, observe the number of chlorine atom and number of magnesium atom in one molecule of magnesium chloride compound, and their formula ($MgCl_2$). Also, observe formula for following compounds such as KCl, $CaCl_2$, HCl, and $ZnCl_2$ and its symbols. ❑ Observe the chemical formula for the following element or compound such as NaCl, $MgCl_2$, KCl, $CaCl_2$, HCl and $ZnCl_2$. ❑ Derive inferences on purpose of representing elements and compound by means of a formula.
17.11.11	Valency with respect Chlorine Oxygen, Calcium, Zinc, Potassium, magnesium Barium	To develop the skill of observation, communication and inference.	Role Play	❑ Observe the role play on valency and symbol of Chlorine (Cl), Oxygen (O_2), Potassium (K), Zinc (Zn), Sodium (Na), and Magnesium (Mg). ❑ Observe the role play of how atoms of different elements combine to form compounds. ❑ Derive inferences on purpose of representing elements or compound by chemical formula like HCl, H_2O, $MgCl_2$, $ZnCl_2$, CaO_2, MgO_2, ZnO_2 and BaO_2. ❑ Make inferences on valency of an element and compounds.
18.11.11	Symbols for different elements	To develop observation and communication	Group activity	❑ Observe different elements and its symbols. ❑ Make tabular column and write symbols for different elements.

19.11.11	What is a Compound Ex: NO, NO_2, CO_2.	To develop the skill of observation, communication inference	Simulation (Simulated Model)	❑ Observe the number of nitrogen and oxygen atoms in nitric oxide (NO) compound. Similarly, number of hydrogen atom and number of oxygen atom in water molecule (H_2O); Number of oxygen atom and nitrogen atom in nitrogen dioxide (NO_2) compound. Number of carbon atom and number of oxygen atoms in CO_2 compounds. ❑ Acquire the skill of writing chemical formula for following compound such NO, NO_2, and CO_2, and derive inferences.
21.11.11	Decomposition of Silver Bromide	To develop the skill of observation, prediction and inference.	Demonstration.	❑ Observe the colour, nature of silver chloride substance. ❑ Predict what will be the reaction when silver chloride kept in sunlight for some time. ❑ Verify the prediction and observe the colour and nature of the products. ❑ Make inference on decompose silver chlorine substances. ❑ Communicate through chemical equation for the above reaction
21.11.11	Formation of Aluminium Iodide compound.	To develop the skill of observation, prediction, communication and inference.	Demonstration cum discussion	❑ Observe the chemical colour and its nature of aluminium iodide. ❑ Predict what will happen after some times. ❑ Verify the prediction by doing experimentation, and observe the procedure of experiment. ❑ Observe the colour and nature after the reaction takes place. ❑ Write the chemical reaction equation. ❑ Derive inferences on formation of aluminium iodide.
22.11.11	Law of Conservation of Mass	To develop the skill of observation, prediction and inference.	Demonstration cum Discussion	❑ Observe the sodium sulphate in the conical flask, and observe the barium sulphate in test tube which is hanged inside the conical flask with the help of thread. ❑ Note down the mass of the solutions.

				❑ Mix each other and notice the colour change during reaction. ❑ Predict about the mass, and colour of the two solutions after mixed each other. ❑ Derive inferences based on inferences.
22.11.11	Sink and floating of Ice Cubes in water.	To develop the skill of observation, prediction, and inference.	Hands on Experience	❑ Observe the ice cubes and predict whether the ice cubes float or sink in water. ❑ Verify the prediction by putting ice cubes into beaker containing water and observe the melting of ice cubes in water ❑ Make inferences based on observations.
24.11.11	CRT (Discovery of Electron)	To develop the skill of observation, communication, and inference.	Multimedia presentation	❑ Watch the videos on CRT and observe the cathode ray tube and its parts. ❑ Draw the CRT and label their parts. ❑ Derive inferences on CRT and its properties.
25.11.11	Static electricity	To develop the skill of observation, inference.	Hands on experience	❑ Observe the bits of paper attracted by rubbed Comb with dry hair ❑ Observed the inflated balloon attracted by rubbed glass rod with a silk cloth. ❑ Derive inferences on static electricity.
25.11.11	Corrosion (Rust of iron nails)	To develop the skill of observation, prediction, inference	Hands on experience	❑ Observe 3 nails which are kept in 3 different test tubes containing calcium chloride, boiled hot water and ordinary water respectively for rusting of iron. ❑ Predict that which are the nails will get corrosion. ❑ Observe the nail which is getting corrosion. ❑ Make inference on rusting of iron.
25.11.11	Potato Osmoscope	To develop the skill of observation, prediction and inference.	Hands on experience	❑ Observe the potato Osmoscope experimental setup, and notice the level of sugar solution.

				❑ Make prediction on osmosis. ❑ After some time observe the level of water and sugar solution in potato and beaker. ❑ Make inference on osmosis based on observations.
25.11.11	Acid base Test	To develop the skill of observation, communication, classification prediction and inference.	Hands on experience	❑ Observe the substances kept for acid base test and litmus paper. ❑ Predict which are the substances are acids and bases. ❑ Draw the tabular column to record their observation. ❑ Classify the acids and bases. ❑ Derive inferences on properties of acids and bases.
28.11.11	Bar diagram and line graph	To develop the skills of Observation, communication and inference.	Hands on Experience	❑ Observe the numerical data displayed on the board for plotting line graph and bar graph. ❑ Draw the bar graph for the given data. ❑ Draw the line graph for the given data. ❑ Make inference based on the graph.
28.11.11	Classification of Animals	To develop the skill of Observation, Classification and Inference.	Multimedia presentation	❑ Observe the animals and insects pictures displayed on the screen. ❑ Classify them based on the similarities and differences. Ex: Animals are classified into vertebrates, invertebrates, insects, unicellular, multicellular, birds, lizards etc... ❑ Derive inferences based on observations.
29.11.11	Pressure exerted by object (Brick) depends upon the area.	To develop the skill of Measurement Observation Communication Prediction and Inference.		❑ Measure the length, breadth and width of brick. ❑ Draw the table and enter the measured data with appropriate units. ❑ Make prediction on in which positions pressure of the brick will be more. ❑ Verify their prediction by experimentation. ❑ Make inferences based on observations.

29.11.11	Liquid exerts Pressure.	To develop the skill of Observation, Prediction and Inference	Hands on Experience	❑ Students asked to predict about the pressure of the water inside the bottle. ❑ Experiment (1) Observe the pressure exerted by water in two different plastic pipes with different height of the water column. ❑ Experiment (2) Observe the pressure exerted by water on the wall of plastic bottle. ❑ Experiment (3) Observe the fall of water from four holes all around near the bottom of the plastic bottle. ❑ Experiment (4) Observe the fall of water from three holes made at different heights from the bottom of plastic bottle. ❑ Derive inferences based on their observations.
29.11.11	Homogenous and heterogeneous mixture	To develop the skill of Observation and Inference.	Hands on Experience	❑ Students observe the substances kept for homogenous mixture and heterogeneous mixture. ❑ Observe the homogenous solution and heterogeneous solution in separate beakers. ❑ Make inference on homogenous mixture and heterogeneous mixture.
30.11.11	Pressure depends up on the density of liquid.	To develop the skill observation, prediction and inference.	Hands on experience	❑ Observe the water in one beaker and castor oil in another beaker same amount, and make prediction on which one will be heavier. ❑ Verify the prediction by doing experiments (students keep one beaker with water in one palm, and another beaker in another palm. ❑ Observe (Feel) the pressure exerted by both the beaker. ❑ Based on observations make inferences.
30.11.11	Air exerts pressure	To develop the skill of observation, inference.	Hands on experience	❑ Students suck and observe the level of water in pipette tube and slowly remove finger from the mouth of pipette. ❑ Make inference based on observations.

30.11.11	Non contact forces (Ex: magnetic force)	To develop the skill of observation and inference.	Hands on experience	❑ Observe the magnetic forces between south and south poles. ❑ Observe the magnetic forces between north and north poles. ❑ Observe the magnetic forces between north and south poles. ❑ Derive inferences based on observations on force of attractions.
30.11.11	Observation of Chemicals	To develop the skill of observation.	Hands on experience	❑ Observe the colour, smell, nature and texture of various chemicals.
02.12.11	Percentage of Hydrogen Ions in Chemicals	To develop the skill of Observation and communication.	Hands on Experience	❑ Observe the different chemicals kept for testing percentage of hydrogen ions. Observe the hydrogen ions in different chemicals. ❑ Draw the tabular column and enter percentage of hydrogen ions of different chemicals. ❑ Based on observations, derive inferences.
02.12.11	Symbols of different Electric Components	To develop the skill of observation and communication.	Group Discussion	❑ Observe the diagram of different electrical components symbols and its meaning. ❑ Draw the different electric component symbols in the tabular column.
09.12.11	Simple, Series and Parallel circuits.	To develop the skill of observation and inference.	Hands on experience	❑ Observe the simple circuit, series circuit and parallel circuit. ❑ Draw the diagram of same. ❑ Based on observations, derive inferences.
09.12.11	Good conductors and Poor conductors	To develop the skill of Observation, Communication and Inference.	Hands on Experience	❑ Observe the different materials/substances (Common salt sol, dilute HCl, lime juice and diesel) kept for conductors and insulators experimentations. ❑ Draw the tabular column and list out names of substances. ❑ Predict which are substances are good conductors and poor conductors. Verify the predictions based on observations and derive inferences on good conductors and poor conductors.

09.12.11	Types of Charges	To develop the skill of observation, prediction and inference.	Hands on Experience	❑ Activity 1: Observe the bits of paper attracted by charged balloon when it brought nearby bits of paper. ❑ Activity 2: Observe the repulsion of two straws having same charges when they brought nearby. ❑ Activity 3: Observe the repulsion between two glass rods having same charges when they brought nearby. ❑ Observe the repulsion between two plastic straws having same charges when they brought nearby. ❑ Observe the attraction between a glass rod and plastic straw having opposite charges when they brought nearby. ❑ After completion of experiment, derive inferences on static electricity.
09.12.11	Expansion of solids on heating (Ball and ring Experiment)	To develop the skill of observation and inference.	Hands on experience	❑ Ball and Ring Experiment: students observe the small metal spherical ball freely entered into the ring before heating. ❑ Observe that the same metal spherical ball not entered inside the ring after heating.. Based on observations make inferences on expansion of solids on heating.
09.12.11	Expansion of gases	To develop the skill of observation and inference.	Demonstra tion	❑ Observe the balloon was fixed on the neck of the bottle and it gets inflate (blows up) when the bottle placed in a bowl of hot water. ❑ After sometimes they observe that the balloon gets contracts (flatten) when the bottle removed from bowl of hot water. ❑ Based on observations students derive inferences.
09.12.11	▪ Conduction of heat in solid	To develop Observation and Inference skills.	Hands on experience	❑ Conduction of heat in Solid: Observe (feel by touch) the heat in one end of the iron rod while supply heat on other end of the same rod. ❑ Derive inferences on transfer of heat in solids.

	▪ Convection of Heat in liquids	To develop Observation and Inference skills		❑ Convection of heat in liquids: Observe the diffusion of potassium permanganate molecules in a beaker containing water. ❑ Derive inferences based on observations of experiment on transfer of heat.
12.12.11 and 13.12.11	Electroplating	To develop the skill of Observe and Inference.	Discussion	❑ Observe the outer surface of metals such as wrist watch, spoon (steel), screws and covering jewellery. ❑ Based on observations, make inferences on electroplating.
02.01.12	Lightning and Thunder formation	To develop the skill of Observation, Prediction and Inference.	Multimedia presentation	❑ Predict the cause for lightning and thunder. ❑ Observe the massive positive and negative charges in the clouds and its movements. ❑ Observe the discharge of electric charges with light and sound. ❑ Derive inferences on lightning and thunder.
02.01.12	Thermal expansion in our daily life (Ex: Railway line, Telephone wire between two poles sag)	To develop the skill of Observation, Prediction and Inference.	Multimedia Presentation	❑ Observe the small gap in the railway lines. ❑ Observe the telephone wires and electric wires sag between two poles in summer. ❑ Make prediction on what may happen the railway line gap, and telephone and electric wires sag after some days. ❑ Derive inferences on thermal expansion.
05.01.12	Laws of reflection of light	To develop the skill of Observation, Communication Measurement and Inference.	Hands on experience	❑ Observe the incident ray and reflected ray in the plane mirror. ❑ Draw the incident ray, reflected ray and normal. ❑ Measure the angle between incident ray and normal, reflected ray and normal. ❑ Derive inference on reflection of light.
05.01.12	Multiple Reflection	To develop the skill of Observation,	Hands on Experience	❑ Observe the multiple reflections and multiple images in two plane mirrors placed parallel to each other.

		Communication Prediction and Inference.		❑ Draw the tabular column to enter number of images in different angles, also draw the diagram. ❑ Predict the number of images in different angles of two plane mirrors placed parallel to each other. Verify the predictions by doing experimentation, and derive inferences.
06.01.12	Refraction	To develop the skill of Observation and Inference.	Hands on experience	❑ Observe the pencil partially immersed in the beaker containing water. ❑ Observe the part of the pencil in water appears to be bent and larger in size. ❑ Observe that the bottom of the beaker looks closer than actual. ❑ Observe the coin in the water which looks closer than actual. ❑ Derive inferences on refraction of light.
06.01.12	Refraction of light (Passing of light rays from rarer medium to denser medium)	To develop the skill of observation and inference.	Hands on experience	❑ Observe the deviation of light rays towards the normal from rarer medium (air) to denser medium (water). Similarly, observe the deviation of light rays away from normal when it travels from denser medium (water) to rarer medium (air), and derive inferences.
06.01.12	Dispersion of light	To develop the skill of observation and inference.	Hands on experience	❑ Observe the different colours of white light in glass prism. ❑ Derive inferences on dispersion of light based on observations.
09.01.12	Sound produced by vibration of body.	To develop the skill of observation and inference	Hands on experience.	❑ Observe (hear) the sound produced by vibration of free end of the scale which is on the table. ❑ Make inference that how the sound is produced. ❑ Observe the photograph of birds sound, loud speaker, and aeroplane, car, firing crackers, beating drums, and barking dogs. ❑ Make inferences sound produced by different organisms.
10.01.12	Sound produced by different objects	To develop the skill observations and inference.	Hands on experience	❑ Observe (hear) different types of sounds produced by each objects such as stick, metal plate, plastic mug, a sheet of paper, a wooden block, a cloth. Derive inferences based on observations.

13.01.12	Sound produced by tuning forks.	To develop the skill of observation and inference.	Hands on experience	❑ Observe (hear) the different types of sounds produced by tuning forks. ❑ Derive inferences that how sound is produced..
19.01.12	Observations of Preserved Animal Specimens	To develop the skill of observation and classification.	Hands on Experience	❑ Observe the body shape, colour, structure, legs, antenna, tentacles, arms, body segments and other bodily features and characteristics of preserved animal Specimens such as snake, shark, snail, star fish, ascaris worm (male and female), prawn, frog, cockroach and earthworm. ❑ Classify them based on similarities and differences
20.01.12	▪ Air Pollution ▪ Water pollution ▪ Land pollution	To develop the skill of Observation, Classification and Inference.	Multimedia presentation	❑ Observe the pictures of air pollutants (industrial emissions, vehicles smoke, power stations and aeroplanes, burning of fuels), land pollutants (fertilizers, pesticides, sewage waters, factory wastes, plastics, wastes cloths etc. and water pollutants (industrial waste water, animal waste, fertilizers, pesticides, sewage water, and waste water by washing vehicles, bathing human and animals. ❑ Based on observations, classify the substances and materials into air pollutants, water pollutants and water pollutants. ❑ Make inferences on pollutions, pollutants and different types of pollution.
20.01.12	Percentage of air present in atmosphere	To develop the communication skill.	Group discussion	❑ Data on percentage of air in atmosphere will be shown for observation (seeing). ❑ Draw the pie chart for the given data on percentage of air in the atmosphere, based on the observations derive inferences.

23.01.12	Sinking and floating of objects/substances in kerosene and water.	To develop the skill of observation and prediction.	Demonstration	❑ Observe the materials/substance kept for sinking and floating test in kerosene and water. ❑ Predict on sinking and floating substance/materials in water. ❑ Verify the prediction by doing experiments, and derive inferences.
24.01.12	Extraction of Petroleum	To develop the skill of observation and inference.	Multimedia presentation	❑ Observe the different fractions of petroleum such as petroleum gas, petrol, kerosene, diesel, lubricating oil, fuel oil, paraffin wax and bitumen in refining process of petroleum fractionating columns. ❑ Derive inferences based on observations.
27.01.12	Alternative sources of energy. (Wind mill and Solar Energy)	To develop the skill of observation, inference.	Multimedia presentation	❑ Observe the wind mill's long blades and dynamo. ❑ Observe the solar cells ❑ Based on observations, derive inferences.
31.01.12	Afforestation and deforestation	To develop the skill of observation and inference	Multimedia presentation	❑ Observe the differences between Afforestation and deforestation video. ❑ Based on observations, derive inferences
02.02.12	Flora and Fauna in India	To develop the skill of observation, communication and inference.	Group Discussion	❑ See (Observe) the numerical data on status of flora and fauna in India which is displayed on blackboard. ❑ Draw the bar diagram for the flora with differentiation. ❑ Draw the pie diagram for the fauna with differentiation. ❑ Based on observations of pie chart, derive inferences.
03.02.12	Organisms and its habitat ▪ Classification of plants ▪ Food web and Food chain	To develop the skill of Observation, Classification, Communication and inference	Field Visit to Gene pool Garden	❑ Observe and draw the display board on classification of plants. ❑ Observe the food chain between different animals in the display board. ❑ Draw the food web between different animals and discuss with others.

	▪ Global warming and green house effect. ▪ Observe the preserved insects and animals in museum. ▪ Observe the fern house (Pteridophytes) ▪ Observe aquatic plants and insects.			❑ Observe the global warming and green house effect display board and draw the same. ❑ Observe the shape, body organs, and nature of body of preserved insects and animals. ❑ Observe the metamorphosis (Different stages) of butterflies. ❑ Draw the different stages of butterflies. ❑ Communicate with others about their observation. ❑ Observe the leaflets, stem, roots, flower and spores of pteridophytes. ❑ Observe different aquatic plants and fish and insects in water tank.
11-02.12	Vermiculture	To develop the skill of Observation.	Field Visit to vermiculture farm	❑ Observe the type of soil, bedding, food and feeding, eggs of earthworm. ❑ Observe the method and procedure of vermiculture. ❑ Observe the earthworm body nature, and segments. ❑ Observe the earthworm movements.

4.3 Acquisition of Basic Science Process Skills during Implementation of Intervention Programme

The Experiential learning intervention programme was implemented and the description of programme implementation is presented below. During implementation of programme Students followed the Kolb's Experiential learning cycle and acquired BSPS in each stage of the cycle.

Date	**:**	**22.08.11**
Content Chosen	**:**	**Agricultural Practices**
Developed Skills	**:**	**Observation Classification Communication and Inference**
Learning Experience	**:**	**Multimedia Presentation**

This was the learning experiences provided through multimedia presentation on different steps of agricultural practices.

- The students were divided into six groups, four to five members in each group but in one group the number of students were three, and they have been seated group wise in multimedia theatre.
- Students gained concrete experiences by watching videos on different steps of agricultural practices such as
  - Ploughing of soil: video were shown about manual ploughing and tractor ploughing.
  - Levelling of soil: video were shown about levelling of soil manually and by machine.
  - Sowing the seed: video were shown about sowing of seeds by manually and by machine.
- Students made reflective observation about different steps of agricultural practices.
- Students noticed the differences between manual and machine ploughing
- Students observed the levelling of soil manually and by machine, and how ploughing helps the soil breaks into smaller.
- Students observed how to sow the seeds into the soil by manually and by machine.
- Students discussed with group members about different agricultural practices, and taken notes, drawn diagram and flow chart for different steps of agricultural practices. They classified dry seeds and fleshy seeds. And they infer that production of crops involves several activities carried out by man or machine over a period of time.

Date	**:**	**23.08.11**
Content Chosen	**:**	**Agricultural Practices**
Developed Skills	**:**	**Observation, Classification Communication and Inference**
Learning Experience	**:**	**Multimedia Presentation**

In the continuation of steps of agricultural practices gained concrete experiences by watching the videos on

- Different types of Irrigation: Students observed the similarities and differences between different types of irrigation such as furrow irrigation, basin irrigation, sprinkler irrigation and drip irrigation.
- Methods of Weeding: Students observed manual and chemical weeding.
- Types of Harvesting: Observed manual and machine harvesting of crops.
- Threshing of Crops: Students observed the separation of grains from stalks.
- They classified fertilizers and weedicides. Also they classified dry fruits, fleshy fruits, cereals, vegetables, grains, pulses, dry storage and cold storage of fruits.
- Students derived inference on different irrigational method, purpose of weeding, harvesting, threshing and storage of seeds.

Date	**: 24.08.11**
Content Chosen	**: Observation of Bean Plant**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Hands on Experience**

- Students gained concrete experience and mead reflective observations through hands on Experiences.
- Students brought a bean plant twig with roots and leaves, group wise they reflectively observed the bean plant twig.
- Students made observation and formulated abstract concepts such as colour of roots, primary, secondary and tertiary roots, roots nodules, root and stem hairs; leaves and its features such as veins, margins etc.
- Students understand and inferred the functions of root nodules.

Date	**:**	**26.08.11**
Content Chosen	**:**	**Physical Changes between Boys and Girls during Puberty, and Endocrine Glands**
Developed Skills	**:**	**Observation and Inference**
Learning Experience	**:**	**Multimedia Presentation**

- Students received learning experience in multimedia theatre by watching videos on physical changes between boys and girls during puberty, and Endocrine glands in human body.

- They made reflective observations on physical changes, for example facial hairs (beard and moustaches for boys), hairs under armpit, under chest, broadening of shoulder, increase in height and weight, change in body shape, change in voice; and increase of sebaceous glands (oil glands) for both boys and girls during puberty.
- Also students observed the location of pituitary glands, thyroid glands, pancreas, adrenal gland, and testes and ovaries.
- They derived inferences on different glands in human body.

Date	**:**	**29. 08.11**
Content Chosen	**:**	**Chromosomes and Sex Determination**
Developed Skills	**:**	**Observation, Communication and Inference**
Learning Experience	**:**	**Multimedia Presentation**

- Learning Experiences provided in the multimedia theatre for getting Concrete experiences and reflective observation.
- Videos on egg cell and sperm cell, and chromosomes were shown to the students, and they have been engaged to observe the shape of egg cell, sperm cells and chromosomes, types and number of chromosomes.
- They classified chromosomes into body chromosomes and sex chromosomes.
- Communicated with others through discussion and drew diagram of egg cell and sperm cell.
- Students predicted which chromosomes is responsible for determine the sex.
- Students inferred total number chromosomes, and types, and chromosomes.

Content Chosen	**: Smoking Hazards.**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Multimedia Presentation**

Concrete learning experiences gained by students in multimedia theatre, and they observed the videos and photograph on effects of smoking in Human organs such as mouth cancer, blockage of nerve cells, constriction of blood vessels, and lining of arteries were shown to the students.

- They discussed with other students within the group about the same.
- Students inferred that smoking cause various diseases to the human organs.

Content Chosen	**: Cancer and its Classification**
Developed Skills	**: Observation Communication and Inference**
Developed Skills	**: Learning Experience**

- Different types of cancer diseases were shown through videos and photograph to the students for getting concrete experience and made reflective observation.

- Students observed different types cancer cells affected Human organs and classified them based on the location of cancer cells.
- They discussed about types of cancers and its effect in Human.
- Students derived inference on different types of cancers and cancer cells.

Date	**:**	**30.08.11**
Content Chosen	**:**	**Observation of Sprouting of Seeds**
Developed Skills	**:**	**Observation Communication Prediction &Inference**
Learning Experience	**:**	**Hands on Learning experience**

Sprouted seeds provided to the students for getting concrete experiences and reflective observation, they engaged in observing germinate the seeds.

- Students observed the colour, structure, layers, hardness, and number of cotyledons of germinated seeds. They discussed about the same within the group members, and draw the structure of seeds.
- They derived inference with regard to factors required for sprouting of seeds.

Date	**:**	**02.09.11**
Content Chosen	**:**	**Types of joints & bones in Human Body and its movements**
Developed Skills	**:**	**Observation Communication and Inference**
Learning Experience	**:**	**Multimedia Presentation**

- Students gained concrete experience in multimedia theatre and made reflective observations on different joints and bones of Human body and its movements.
- Video and still photograph on different types of joints and bones shown for observation. Students observed the elbow joints, thigh joint, gliding joint and pivot joint, and ball and socket joint. Also they noticed the fine details like formation of ligament, red and yellow marrow in the bones.
- They also observed the similarities and differences between different bones.
- Students discussed with others within the group members, taken notes and drew the structure of human skeleton, and structure of different bones.
- They derived inferences on functions and movements of bones and joint.

Date	**: 05.09.11**
Content Chosen	**: Human Skeleton**
Developed Skills	**: Observation and Communication**
Learning Experience	**: Hands on Experience**

- Students gained concrete learning experiences by observing the mounted Human skeleton in laboratory. They noticed reflective observation about the different bones and joints and their movement.

- Students observed the skull, number of rip bones, femur bone, thigh bone, shoulder bone, vertebral column. And they formulated abstract concepts by active experimentation.
- They actively discussed with other students, taken notes, drew the diagram.
- Based on the observations, they derived inferences.

Date	**:**	**06.09.11**
Content Chosen	**:**	**Observations of organisms (Fish, Earthworm and Cockroach)**
Developed Skills	**:**	**Observation, Communication, and Inference**
Learning Experience	**:**	**Hands on Experience**

Students gained concrete experiences by observing the live Fish, Earthworm and Cockroach, also they observed the movements.

- Each organism (fish, Earthworm and Cockroach) were given to different groups for reflective observations.
- Each group observed the fish body shape, fins, colour, nature of body and its locomotion etc. Similarly, they observed earthworm body structure, shape, nature, segments, moisturisers, colour and its locomotion etc. Also they observed body structure, feathers, tentacles, segments, legs and different parts of the body and its movements.
- Students discussed their observations within the group members and they drawn the diagram of fish, cockroach and earthworm.
- Students made inference with regard to fish, earthworm and cockroach body shape and structure and movements.

Date	**: 08.09.11**
Content Chosen	**: Different Types of Irrigation**
Developed Skills	**: Observation Communication**
Learning Experience	**: Simulated Models**

- Concrete experiences experienced by making simulated models of different types of irrigation.
- Students were grouped into four groups; each group prepared one simulated models of irrigation with the help of low cost materials.
- There were four simulated models irrigation such as canal irrigation, sprinkler irrigation, basin irrigation and drip irrigation made by them. All the simulated models kept for observations, each group were engaged to observe the similarities and differences between different types of irrigation.
- During observation, students discuss with other group members and draw the diagram of simulate models.
- Students infer that different irrigational methods used for different types of crops. Also they infer that the advantage of different irrigational methods.

Content Chosen	**: Observation of Fungi**
Developed Skills	**: Observation, Communication and Inference**
Learning Experience	**: Hands on Experience**

Concrete learning experience gained by students by observing the fungi specimens.

- Students observed the smell, colour, rough or hardness of fungi, other details of fungi, based on observation they formulated the abstract concepts.
- During observation students draw the diagram and they discussed within the group members about their observations, and then they inferred**.**

Date	**:**	**12.09.11**
Content Chosen	**:**	**Difference between Monocot and Dicot plants.**
Developed Skills	**:**	**Observation Classification Communication and Inference**
Learning Experience	**:**	**Field Visit**

Students gained concrete experience in the field.

- They observed reflectively about the morphological characteristics of monocots and dicots roots, stem, leaves and flowers. Also they identified similarities and differences between monocots and dicots plants.
- Based on their observations, students formulated abstract concepts on monocots and dicots. They classified monocots and dicots plants based on the presence and absence of certain characteristics.
- They inferred that monocots are differing from dicots in terms of flower, leaf and roots.

Date	**:**	**13.09.11**
Content Chosen	**:**	**Bryophytes and its Classification**
Developed Skills	**:**	**Observation Classification Communication and Inference**
Learning Experience	**:**	**Multimedia Presentation**

- Students received concrete learning experiences in multimedia theatre.
- Videos and still photograph of bryophytes were shown to the students for making reflective observation. Students observed the bryophytes root, stem and leaf like structures. And they formulated abstract concepts based on their observations.
- Students classified different types of bryophytes based on presence and absence of similarities and differences.
- Students derived inferences about bryophytes and its living habitat, nature of plants.

Date	:	**14.09.11**
Content Chosen	:	**Algae and its classification**
Developed Skills	:	**Observation Classification Communication and Inference**
Learning Experience	:	**Multimedia Presentation**

- Students received concrete learning experiences in multimedia theatre on algae and its classification.
- Students observed different types of algae and morphological structure of root, stem and leaf. Based on the presence and absence pigments, students classified algae into four categories.
- Students drew diagram of different types of algae and discussed with group members about their observations. They derived inferences.

Date	**: 13.09.11**
Content Chosen	**: Observation of Earthworm**
Developed Skill	**: Observation Communication and Inference**
Learning Experience	**: Hands on experiences**

- Concrete learning experiences gained by students through Hands on experience.
- Students' observed earthworm size, shape, body structure, body segments, and movements. Based on the observations, they formulated abstract concepts and discussed with group members; also they drew the diagram of earthworm. After observations students derived inference on earthworm.

Date	**: 15.09.11**
Content Chosen	**: Observation of Anatomy of Dicot root**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Hands on experience**

- Concrete learning experiences gained by operating simple microscope.
- A mounted dicot root slide was focused in the microscope and observed dicot root slide.
- They operated microscope and observed the shape, types and arrangement of cells in the roots from periphery to centre.
- Based on their observation of root cells, abstract concepts were formulated and actively done experimentation.
- They taken notes drew diagram of dicot root and labelled neatly.
- Students observed the microscope and its parts, and practical skills.
- Derived inference on functions of cells.

Date	**: 16.09.11**
Content Chosen	**: Observation of Anatomy of Dicot stem**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Hands on Experience**

- Students gained concrete learning experiences by observing the anatomy of dicot stem structure in simple microscope.
- They observed shape, arrangement of different types of cells from periphery to centre. Also, they identified the similarities and differences between dicot root and dicot stem with respect to arrangement and type of cells.
- They drew and labelled the dicot stem and they discussed with other students about their observations.
- Based on their observations abstract concepts were formulated, further actively they were doing experimentation.
- Students derived inferences based on observations.
- Students observed the parts of microscope, and they acquired the practical skill on how to operate the microscope.

Content Chosen	**: Observation of anatomy of Dicot leaf**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Hands on Experience**

- Students gained concrete learning experiences by observing the anatomy of dicot leaf structure in simple microscope.
- They observed shape of the cells, arrangement and location of different types of cells from periphery to centre. Students identified the similarities and differences in arrangement of cells and type of cells between dicot root and dicot stem and dicot leaf. They drew and labelled the anatomical structure of dicot leaf.
- Bases on observations, abstract concepts were formulated and actively done experimentation. Students observed the microscope and its parts, and acquired the practical skill on how to operate the microscope.

Date	**: 17.09.11**
Content Chosen	**: Tobacco Effects on Human**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Group Activity**

- Group wise students collected information with regard to tobacco effects on Human body and gained concrete experience.
- Each group collected information from various sources through newspaper, posters, wallpapers etc, they prepared a chart and displayed in the class.

- Group wise students presented in front of classroom, students other than presenters were observed reflectively, they discussed shared their observations and improved their communication skills. Based on the observations, they formulated abstract concepts.

Date	**:**	**19.09.11**
Content Chosen	**:**	**Observation of Monocot and Dicot Seeds**
Developed Skills	**:**	**Observation Classification Communication and Inference**
Learning Experience	**:**	**Hands on Experience**

- Students gained concrete experiences by observing the morphological characteristics of both dicot and monocot seeds.
- Students reflectively observed the colour, shape, harness, softness, nature, and number and other features of dicot and monocot seeds.
- Based on observations students formulated abstract concepts on monocots and dicots seeds, and derived inferences.
- They discussed, drew the diagram. And actively experimented by classifying the given seeds such as paddy, wheat, bean, pea, mango into dicots and monocot seeds based on similarities and differences.

Date	**:**	**20.09.11**
Content Chosen	**:**	**Morphological of Monocot and Dicot Plants**
Developed Skills	**:**	**Observation Classification Communication and Inference**
Learning Experience	**:**	**Field Visit**

- Students gained concrete learning experience by exposing them in the field.
- They observed characteristics of different plants formulated abstract concepts, and the same discussed with group members, and drew diagram.
- Based on their observations, they derived inferences.

Date	**:**	**10.09.11**
Content Chosen	**:**	**Micro organisms**
Developed Skill	**:**	**Observation Classification and Inference**
Learning Experience	**:**	**Multimedia Presentation**

- Students received concrete experiences in multimedia theatre by watching videos on micro organisms such as different types of viruses, bacteria, Fungi, and Chlamydomonas.
- Videos and still photograph of different types of viruses, ultra structure of bacteria, and Chlamydomonas were shown. Students made reflective observation in terms of shapes structure number of flagella and their movements
- Based on their observations students formulated the abstract concepts on viruses, bacterium and Chlamydomonas.

- Students discussed with other students within the group about their observations, and drew diagram of viruses, Bacterial cell and Chlamydomonas.
- They classified the viruses based on the hosts, and presence and absence of nucleic acids.
- After a thorough observations and classifications, they derived inferences on bacteria and viruses and Chlamydomonas.

Date	**: 11.10.11**
Content Chosen	**: Fermentation**
Developed Skills	**: Observation Prediction and Inference**
Learning Experience	**: Hands on Experience**

- Direct hands on experiences gained by the students by doing experiments on fermentation.
- Before experiments, students observed the materials (Kuhn's fermentation tube, sugar solution, and yeast) required for doing fermentation experiments. And they predicted, what will happen if yeast is mixed with sugar solution in Kuhn's fermentation tube.
- To verify their prediction, students have done active experimentation on fermentation and made reflective observations. After completion of experiments, students observed smell, colour, and level of sugar solution in the Kuhn's fermentation tube.
- Based on observations, they derived inferences on fermentation.

Date	:	**13.10.11**
Content Chosen	:	**Observation of root nodules, citrus canker leaf, bread mould**
Developed Skills	:	**Observation Communication Inference**
Learning Experience	:	**Hands on experience**

Students divided into different groups and each group seated in different places inside the classroom and they have been given real plant specimens of root Nodules of leguminacious plant, infected citrus canker leaf, and bread mould for observations. Each group was engaged to observe the given specimens, after completion of their observation, they have shifted to observe other specimens. Likewise group rotation were done till completion of observation of all specimens by all the groups.

Content Chosen	**: Observation of Root Nodules in bean Plant**
Developed Skill	**: Observation Communication and Inference**

- Concrete experiences gained by the students by observing the root nodules in leguminacious plant. Roots of bean plant (leguminacious plant) distributed to each groups for observation.

- ❑ They made reflective observation in terms of colour, primary, secondary and tertiary roots and root nodules. Based on the observation, students made abstract concepts and derived inferences.
- ❑ They drew the structure of root nodules and communicate with other within the group members to discuss about the same.

Content Chosen	**: Observation of infected citrus canker Leaf**
Developed Skills	**:Observation Communication Prediction and Inference**

- ❑ Concrete Experiences gained by another group of students with regard to observation of infected citrus canker leaf.
- ❑ Infected citrus canker leaf was distributed to group for observation, and they observed the colour and other characteristics infected leaf.
- ❑ Based on the observations, they made abstract concepts. Also students discussed with others and drew the diagram of leaf.
- ❑ Students predicted that what may happen to the leaf after two or three days, Students predicted that the entire leaf will be infected and it will become decolourise.
- ❑ Students derived inference on the infection of leaf due to micro organisms therefore some part of leaf is brown and black in colour.

Content Chosen	**: Observation of bread mould**
Developed Skills	**: Observation Communication and Inference**

- ❑ Decayed bread mould has been given to the group of students for getting concrete experiences. And they observed carefully about the colour, smell, appearance of the bread.
- ❑ Students discussed the same with other students within the group members; also they drew the diagram and labelled neatly.
- ❑ They formulated abstract concepts; later they derived inference that the bread was infected by micro organisms called fungi, so that the colour, smell and whitish sponge network like appearance formed on the surface of the bread.

Date	**: 24.09.11**
Content Chosen	**: Binary fission of Bacteria.**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Multimedia Presentation**

Students gained concrete experiences in multimedia theatre by watching videos on binary fission of bacteria.

- ❑ Students observed different stages of bacterial fission, and formulated the abstract concepts. They draw the diagram of binary fission of bacteria and flow chart, also they discussed with other students about their observations.

- Based on the observations students derived inference on binary fission of bacterium.

Date	**: 25.10.11**
Content Chosen	**: Bacteria and its Types**
Developed Skills	**:Observation Classification and Inference**
Learning Experience	**: Multimedia Presentation**

- Concrete experiences provided in the multimedia theatre by showing videos and still photograph on different types of bacteria.
- Videos and photograph on different types of bacteria were shown to students for reflective observation. Students observed different types of bacteria such as round shape, rod shape, and cork shape, and comma shape bacteria. Also students observed the number of flagella in bacteria accordingly they classified the bacteria into different types.
- They discussed with students about their observations and developed abstract concepts.
- Based on the observations, students inferred derived inferences.

Date	**:**	**27.10.11**
Content Chosen	**:**	**Degradable and non-degradable materials**
Developed Skills	**:**	**Observation Classification Communication Prediction and Inference**
Learning Experience	**:**	**Hands on experience**

- Students have done active experimentation on degradable and non degradable experiment to get concrete learning experience.
- Different types of degradable materials such as waste foods, fruits, vegetable waste were put into one bottle, similarly non degradable materials such as plastic, piece of nails, glass pieces were put into another bottle. Students observed all the materials and predicted that degradable and non degradable materials. By doing active experimentation, students gained concrete experience. And they made reflective observations.
- Two bottles were kept in the corner of classroom for two days, after two days they have observed the smell, colour of degradable and non degradable materials kept in two bottles. Based on their observations students derived inferences with regard to degradable and non degradable.

Date	**: 01.11.11 and 02.11.11**
Content Chosen	**: Plant Cell and Animal Cell and its organelles**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Multimedia Presentation**

Students gained concrete experiences in multimedia theatre by watching videos on plant and animal cell.

- Videos on plant cell and animals cells were shown to them for observations, they observed the shape of plant and animal cell, presence and absence of cell organelles. Also they identified the similarities and differences between plant and animal cells.
- Students also observed the structure and shape of cell organelles such as Endoplasmic Reticulum, Ribosome, Golgi apparatus, Lysosomes, Mitochondria, Chloroplast and Centrioles.
- Students discussed with other students about their observations, and formulated abstract concepts. They drew the diagram of plant cell and animal cell, and their organelles separately.
- Students infer that plant cell and animals' cells differ in their shape, structures, and presence and absence of certain cell organelles.

Date	**: 03.11.11 and 05.11.11**
Content Chosen	**: Types of Human Cells**
Developed Skills	**: Observation Communication and Inference**
Learning Experiences	**: Multimedia Presentation**

- Concrete learning experiences provided in multimedia theatre by showing the videos and still photograph on different types of Human cells.
- Students observed the shape and structure of fat cells, sperm cells, bone cells, blood cells, and smooth cells.
- Students interacted with other students and drew the structure of different cells and labelled it correctly.
- Based on their observation of different types of cells, students formulated the abstract concepts. And inferred that different types of Human cells perform different functions.

Content Chosen	**: Human eye and Kidney**
Developed Skills	**: Observation and Communication**
Learning experiences	**: Simulated Models**

Group wise students made model of Human eye and Kidney, by making models they got concrete experience. They made reflective observation.

- Students drew the diagram and labelled the parts.
- After observation students discussed with other group members and formulated abstract concepts.

Date	**:**	**08.11.11**
Content Chosen	**:**	**Measurements**
Developed Skills	**:**	**Observation Measurement Communication and Prediction**
Learning Experience	**:**	**Hands on Experience**

Students have been divided into different groups and they were engaged in different learning experiences such as measuring the temperature of Human body, measure the volume of liquids using measurement jar, measure the simple pendulum, measure length breadth height of object using measurement tap, measure the weigh object using spring balance, measure diameter of wire using screw gauge. Each student in a group performed the experiments and gained Hands on learning experiences. After completion of experiments by each group, they have shifted to perform other experiments, likewise group rotation was done till completion of all the experiments by the entire group.

Content Chosen	:	**Measure temperature of Human body**
Developed Skills	:	**Observation, measurement and prediction**
Learning Experience	:	**Hands on Experience**

- Students gained concrete learning experience by measuring the temperature of water and human body with the help of thermometer.
- A thermometer and a beaker with water given to measure the temperature of water.
- Students actively engaged in experimentation by keeping the thermometer in the beaker containing water and measured the temperature of water. Students received concrete experience, and made reflective observations while measuring the temperature of water.
- Similarly, students measured their body temperature by holding bulb of the thermometer.
- After completion of measurement they written the measurement with appropriate units (in Celsius).
- Based on observation, students predicted other students' body temperature and room temperature. They verified their prediction by doing experimentation actively.

Content Chosen	:	**Measure the Volume of Liquid using measurement jar**
Developed Skills	:	**Observation measurement**
Learning Experience	:	**Hands on Experience**

Hands on learning experiences provided to the group of students for measuring the liquids using measurement jar.

- A graduated measurement jar (1 litre) with water and empty measurement Jar (100 ml) was provided to another group of students.
- Students observed the numerical scales mentioned in the jar, and measured exact 70 ml of water with the help of hundred ml measurement jar.
- While measuring the liquid (water), they got concrete experience and made reflective observation accurately i.e. without lower and upper meniscus.
- After completion of measurement of liquids, students written measurement with appropriate units.

Content Chosen	**: Simple Pendulum Experiment**
Developed Skills	**: Observation Communication Measurement Prediction and Inference**
Learning Experience	**: Hands on Experience**

- ❑ Students gained hands on experience by doing simple pendulum experiment.
- ❑ Students accurately measured the length of the pendulum from the point of suspension to the centre of bob by using the measurement scale (Plate_4.2). After that, they made to oscillate the pendulum and recorded the time taken for ten oscillations; finally they calculated the time taken for one oscillation. Students had drawn the tabular column and entered the data on length of the pendulum, time taken for ten oscillations and time taken for one oscillation.
- ❑ During the entire experimentation students got concrete experience made, reflective observation, active experimentation and abstract conceptualisation.
- ❑ Based on the experiments, students made prediction that if length increased or decreased, what will be the time period of oscillation. They verified their prediction by actively engaged in experimentation. Based on experiences, students derived inferences.

Plate_4.2: Students Measuring the Length of Simple Pendulum

Content Chosen	**: Measure the length, breadth and height**
Developed Skills	**: Measurement Communication**
Learning Experience	**: Hands on Experience**

- ❑ Hands on learning experience provided for the students to measure the length breadth and height of the table which is placed in the classroom.
- ❑ Measurement tape has been given to the students, and then each student in a group measured the length, breadth and height of the table, while measuring the table students reflectively observed and noted down the measurement.
- ❑ After measurements, students written the measurement in appropriate units.

Content Chosen	**: How to Weigh the Object using Balance**
Developed Skills	**: Measurement**
Learning Experience	**: Hands on Experience**

- ❑ Students received concrete hands on learning experience by measuring their weight using flat balance; they measured their own weights carefully.
- ❑ A flat balance was given to them and they measured their own weight of the body by using flat balance.
- ❑ Each student weighed their weights, and the weight was carefully observed and written in appropriate units.

Date	**: 09.11.11**
Content Chosen	**: Measure the thickness of book and one page**
Developed Skills	**: Measurement and observation**
Learning Experience	**: Hands on Experience**

- ❑ The hands on learning experiences provided for the students to measure thickness of book and one page (which is less than one mm).
- ❑ Students measured the thickness of science text book from page number one to last with the help of measurement scale, after completion of measurement they find out the thickness of one page. And the same written with appropriate measurement units.
- ❑ During the measurement students actively engaged in experimentation and gained concrete experience followed by reflective observations.

Content Chosen	**: Measurement of Volume of irregular objects (stone)**
Developed Skills	**: Observation Measurement and Inference**
Learning Experience	**: Hands on Experience**

- ❑ Students received concrete learning experience by measuring the volume of irregular objects (Stone).
- ❑ Students observed the materials such as graduated beaker with water (1 litre), irregular stone tied with thread which are kept for experimentation. Students started the measurement experiment actively for getting concrete experiences.
- ❑ They observed and noted down the initial level of water kept in the graduated jar, after sometimes the objects (stone) was immersed into the water with the help of thread, and then students observed and recorded the final level of water in the graduated jar after immersion of stone.
- ❑ In order to find out the volume of irregular objects, students calculated the volume of stone.
- ❑ Based on the observations, students formulated the abstract concepts and derived inference.

Content Chosen	**: Flow of current in the wire measured by ammeter**
Developed Skills	**: Observation Measurement**
Learning Experience	**: Demonstration and Hands on Experience**

- ❑ In order to get concrete learning experience and reflective observations, researcher demonstrated the experiment by connecting wire with battery and ammeter, and students observed the deflection of needle in ammeter.
- ❑ Based on the observations, students formulated abstract concepts and tested the concepts by repeating the experiment.
- ❑ Similarly, students repeated the experiments by doing active experimentation and made reflective observations.
- ❑ Based on the observations, students derived inference that the wires carry current; hence there was a deflection of needle in the ammeter.

Content Chosen	**: Measure the temperature**
Developed Skills	**: Observation and Measurement**
Learning Experience	**: Hands on Experience**

- ❑ Students have done active experimentation by measuring the temperature of classroom in Celsius and Fahrenheit scale, and they got concrete experience.
- ❑ While doing experimentation, students made reflective observations.
- ❑ By measuring and observing the temperature of classroom, students received concrete experience, and observed reflectively.
- ❑ After measurement, students written with appropriate measurement unit.

Content Chosen	**: How to Measure the angle between two lines**
Developed Skills	**: Observation and Measurement**
Learning Experience	**: Hands on Experience**

- ❑ Student measured the angles between two lines with the help of protractor and gained concrete learning experience.
- ❑ They made reflective observation during measurements of angles.
- ❑ After measurement, they written with appropriate measurement units.

Content Chosen	**: Pipette out the water using pipette tube**
Developed Skills	**: Observation and Measurement**
Learning Experience	**: Hands on Experience**

- ❑ Students have done active experimentation by pipette out 20 ml of water exactly from the beaker by using pipette and they gained concrete experiences.
- ❑ They made reflective observations while measuring the water.
- ❑ After measurement, they written with appropriate measurement unit.

Date : 10.11.11
Content Chosen : Observation of Specimens (plants and animals)
Developed Skills : Observation Classification and Inference
Learning Experience : Hands on Experience

- Students gained concrete learning experience by observing preserved plants and animals' specimens in laboratory.
- Plants and animal specimens observed by each group wise students observed, colour, shape, structure, body nature of given plants and animals.
- After observations of plants and animals, students classified the organisms based on the similarities and differences, and grouped them into different categories.
- Students formulated the abstract concepts on plants and animals, and derived inference.

Date : 11.11.11
Content Chosen : Percentage of Elements on Earth, and Human Body
Developed Skills : Observation Communication and Inference
Learning experience : Hands on Experience

- Concrete learning experience gained by students by drawing pie chart for the given numerical data on percentage of different elements on earth crust and the percentage of different elements in Human body.
- Students reflectively observed the numerical data, accordingly they drawn the pie chart correctly and completely.
- Based on the observations of pie chart, students formulated concepts and derived inferences.

Date : 11.11.11
Content Chosen : Classification of Matter (Solids, Liquids, and Gas)
Developed Skills : Observation Classification Communication
Learning Experience : Hands on Experience

- In order to get concrete experience, different materials and substances such as scale, pen, pencil, book, carbon, silicon, gold, mercury, water, oil, fuming agarpathi, inflated balloon, oxygen, nitrogen and hydrogen were shown to the students.
- Students observed the materials and substances reflectively, and classified based on similarities and differences, i.e. they classified into solids, liquids and gas.
- After classification of materials and substances, they inferred that the matter exists in three states that are solids liquids and gas.

Date	**: 11.11.11**
Concept Chosen	**: Classification of Elements**
Developed Skills	**: Observation Classification Communication and Inference**
Learning Experience	**: Hands on experience**

- Student gained concrete experience by making reflective observation on different materials/substances such as copper, gold, silver, iron, hydrogen, oxygen, sulphur, carbon, boron, silicon.
- Based on the observations of similarities and differences between the materials/substances, students classified into metals, non metals and metalloids; and they also formulated abstract concepts.
- They derived inferences that metals are good conductors, and non metals are poor conductors. Also they derived inferences on metalloids.

Date	**: 11.11.11**
Content Chosen	**: Elements (Ex: Hydrogen and Oxygen)**
Developed Skills	**: Observation, Communication and Inference**
Learning Experience	**: Simulation**

- Students made two simulated models with the help of inflated balloon. One for the element Hydrogen (H_2) and other for the element Oxygen (O_2). The name of the elements written on the inflated balloons. By making models, students got concrete experience.
- They made reflective observation by observing the name of the elements, symbol of elements, States of elements (Gas).
- Based on the observations of symbols, chemical formula (Symbol), students acquired communication skill.
- They made abstract concepts and derived inference on chemical formula for a particular element or compound.

Date	**: 14.11.11**
Content Chosen	**: Name of the Elements and its Symbols**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Group Discussion**

- Different elements name which are listed on the blackboard. Students observed the list of elements name such as Boron, Carbon, Fluorine, Hydrogen, Iodine, Aluminium, Barium, Bromine and Lithium etc.
- Students drawn the tabular column and written all those names of elements and its symbol.

- By writing the elements names, symbols, students developed communication skill.
- By seeing different elements names, students formulated abstract concepts on how to what write elements names and symbols.
- Students discussed and interacted with others, and made inference that all elements can be represented by symbols for example Boron (B), Carbon (C), Fluorine (F), Hydrogen (H), Iodine (I), Aluminium (Al), Barium (Ba) Bromine (Br) Lithium (Li) etc. By engaging in group activity students got concrete experience.

Date	**: 14.11.11**
Concept	**: Pictorial Symbols of Elements**
Developed Skill	**: Observation Communication and Inference**
Learning Experience	**: Group Discussion**

- Concrete experience provided to the students to observe the pictorial symbols for different elements which were displayed on the blackboard.
- Students carefully observed the similarities and differences between different pictorial symbols, and the same they drawn.
- Based on the observations, students derived inference on name of elements corresponding to the pictorial symbols.

Date	**: 14.11.11**
Content Chosen	**: Sugar is a Compound**
Developed Skills	**: Observation Prediction and Inference**
Learning Experience	**: Hands on Experience**

- In order to get concrete experience, researcher demonstrated the experiment on sugar is a compound. Students made reflective observations.
- Some amount of sugar has been taken in a test tube and heated over candle flame. During heating of sugar, students observed and predicted that what will happen if the sugar is heated continuously.
- Students proposed many predictions and formulated abstract concepts.
- After observing the demonstration, students repeated the same experiment actively and got concrete experience. They noticed that black colour carbon and water droplets inside the test tube.
- Based on the observations, students inferred that sugar is a compound; and it is a combination of oxygen, hydrogen and carbon.

Content Chosen	**: Observation of lighted Candle**
Developed Skills	**: Observation**
Learning Experience	**: Hands on Experience**

- Concrete experience gained by students by observing the lighted candle.
- A lighted candle was placed on the table, students observed reflectively.
- Students observed and discussed with other students about their observation.
- Based on their observation, students formulated abstract concepts.

Date	**: 16.11.11**
Content Chosen	**: Experiment on Floating and Sinking of Egg in Water and Acetic acid**
Developed Skills	**: Observation, Prediction and Inference**
Learning Experience	**: Hands on Experience**

- Egg, water and acetic acid were shown for observation. Students made prediction on floating and sinking of eggs.
- To verified their prediction, students actively done experiments by dropping the eggs in water and acetic acid separately, and gained concrete experience, made reflective observation.
- Based on the observations, students formulated abstract concepts and derived inferences.

Date	**: 16. 11.11**
Content Chosen	**: Molecule of Compound (Ex: HCl and H_2O)**
Skills Developed	**: Observation, Communication and Inference**
Learning Experience	**: Role Play**

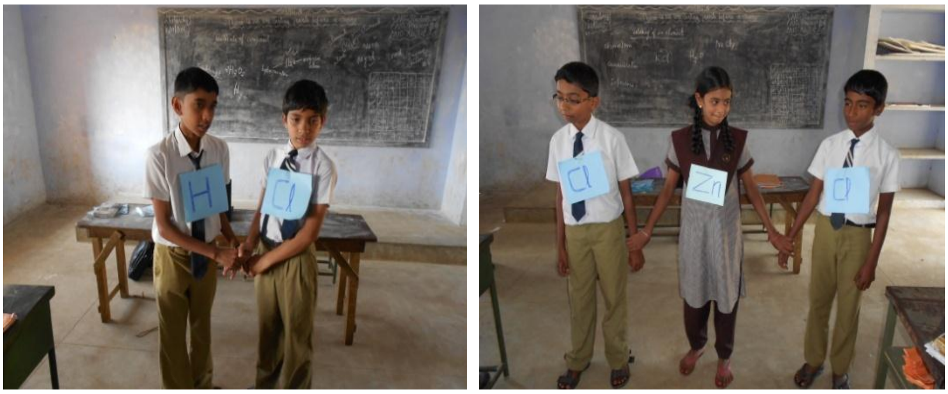
- Students divided into groups (two to three students in a group) to play as the role of molecule of Compound such as HCl and H_2O.
- On a separate card, symbol of Hydrogen (H) and Symbol of Chlorine (Cl), also symbol of Hydrogen (H_2) and Symbol of (O) was written and given to the students.
- Students were played as the role of one Hydrogen atom and one Chlorine atom and formation of Hydro Chloric acid (HCL) compound. Similarly, students they played as the role of two atom of Hydrogen (H_2) and one atom of Oxygen (O_2) and formation of water (H_2O) compound.
- While playing the role of compound formation such as HCl and H_2O, Students got concrete experiences, and observed the symbol of hydrogen, oxygen, and symbol of compound. Also they formulated abstract concepts and derived inferences on number of Hydrogen atom and number of Chlorine atom in one molecule of HCL and H_2O compound.

Date	**: 16.11.11**
Content Chosen	**: Formation of Element and Compound**
Developed Skills	**: Observation Communication Classification and Inference**
Learning Experience	**: Role play**

Students engaged in role play and gained concrete experience. They actively performed the role play and made reflective observations (Plate No_ 4.3).

- Students divided into different groups (two to three students in a group) to play as the role of different elements and Compounds.
- Separate card had been given to students on which symbol of Sodium (Na), Chlorine (Cl), Magnesium (Mg), Potassium (K), Hydrogen (H_2), Calcium (Ca) and Zinc (Zn) was written.
- Group wise students played the role as elements and compounds.
- (i) Two students played as a role of Sodium (Na) and Chlorine (Cl) respectively and they combined to show the formation of sodium chloride compound (NaCl). Similarly, two students acted as Potassium (K) and Chlorine (Cl) combined to show the formation of Potassium Chloride (KCl) Compound.
- (ii)Two students played as a role of two atom of chlorine (Cl) and both they combined with one student who played as one molecule of magnesium (Mg), all the three combined to show the formation of magnesium chloride ($MgCl_2$) compound.
- (iii)Two students acted a role of Hydrogen (H) and Chlorine (Cl) respectively, they combined to form the formation of Hydrogen Chloride compound (HCl).
- (iv)Two students were acted as the role of Chlorine (Cl) and one student acted as the role of Zinc (Zn), and they all together combined to show zinc chloride ($ZnCl_2$) compound.
- (v)Similarly, one student acted like Calcium (Ca) and another two students played as Chlorine (Cl) respectively, all the three students combined together and shown the Calcium chloride ($CaCl_2$) compound.
- While playing the role of different elements and compounds, other students were observed communicated classified and inferred. All the students got concrete experience while they engaged in role play, also they made observation reflectively.
- While watching the role play, students acquire the skill of writing symbols for element and compounds. And they classified elements, compounds based on similarities and differences.
- After completion of role play, students inferred the meaning of elements and compounds.

Plate_4.3: Students Performing the Role play



Date	**: 17.11.11**
Content Chosen	**: Valency for different elements**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Role Play**

- Students were divided into different groups (two to three students in a group) to play as the role of Valency of different elements, and group wise they have played the role of valency for different elements.
- Concrete learning experience gained by students while playing as a role of valency of following elements such as Chlorine (Cl), Oxygen (O_2) Calcium (Ca), Zinc (Zn), Potassium (K), Magnesium (Mg) and Barium (Ba).
- Students had been given a separate card on which symbol of Chlorine (Cl), Oxygen (O_2) Calcium (Ca), Zinc (Zn), Potassium (K), Magnesium (Mg) and Barium (Ba) was written.
- While one group of students played a role of element, and rest of the students engaged in observation. While playing the role play, students observed, formulated abstract concepts and derived inference.

Date	**: 18.11.11**
Concept Chosen	**: Symbols of different Elements**
Developed Skills	**: Observation and Communication**
Learning Experience	**: Group activity**

- Concrete learning experience provided to the students through group activity on symbols of different elements.
- Students made reflective observation on elements and its symbols in chart, and blackboard, and drew the tabular column to write symbols for different elements.
- Students developed communication skill by writing the elements names in the form of symbol.
- Based on their observations, they formulated abstract concepts and derived valid inferences with regard to purpose of writing symbol for elements.

Date	**: 19.11.11**
Concept Chosen	**: What is Compounds (Ex: NO, NO_2, CO_2)**
Developed Skills	**: Observation, Communication and Inference**
Learning Experience	**: Simulation**

In order to get concrete experience, students prepared simulated models with the help of balloon for the following compound such as Nitric oxide (NO), Water (H_2O), Nitrogen dioxide (NO_2) and Carbon dioxide (CO_2) with the help of balloon (Plate_4.4).

- ❑ Students observed (i) simulated model (balloon) of nitrogen atom and oxygen atom combined to form nitric oxide (NO) compound.
- ❑ Students made reflective observation on two atoms of hydrogen (H_2) and one atom of Oxygen (O) in one molecule of water (H_2O).
- ❑ Students made reflective observation on (ii) Simulated model (balloon) of two oxygen atoms and one nitrogen atom in one molecule of Nitrogen dioxide (NO_2) compound.
- ❑ Students observed (iii) Simulated model (balloon) of two oxygen atoms and one carbon atom in one molecule of carbon dioxide (CO_2) compound.
- ❑ By observing the simulated models, students acquired the skill of writing symbol for compounds. Based on observation of simulated models, they formulated abstract concepts and inferred.

Plate_4.4: Simulated Models of Chemical Compounds

Date	**:**	**21.11.11**
Content Chosen	**:**	**Decomposition of Silver Bromide**
Developed Skills	**:**	**Observation Prediction Communication& Inference**
Learning Experience	**:**	**Demonstration**

- ❑ Concrete experience gained by the students by observing the demonstration on decomposition of silver bromide. They made reflective observation on the experiment.
- ❑ Few amounts of silver bromide chemicals were taken in a glass saucer and it was shown to the students for reflective observations.

- Student observed the colour, nature and appearance of silver bromide chemicals, and they predicted about the changer of colour, appearance etc. After sometimes students noticed the decomposition of compound. Based on the observations, they formulated abstract concepts and derived inferences.

Date	**: 21.11.11**
Concept Chosen	**: Formation of Aluminium Iodide Compound.**
Developed Skills	**: Observation Prediction Communication and Inference**
Learning Experience	**: Demonstration**

- Students gained concrete experience by watching the demonstration on formation of Aluminium Iodine compound (chemical reaction experiment).
- Few amounts of Aluminium and Iodine were taken in a china dish and it was shown for reflective observation. Students observed the colour and nature of chemicals, and they were engaged to predict about the future events.
- After sometimes students observed the Aluminium Iodine compound in the same china dish. Based on the observations students formulated abstract concepts and inferred that Aluminium Iodine is a compound formed by combining of two elements.

Date	**: 22.11.11**
Concept Chosen	**: Law of Conservation of Mass**
Developed Skill	**: Observation, Prediction and Inference**
Learning Experience	**: Demonstration**

- Researcher demonstrated an experiment on conservation of mass for the students to get concrete experience.
- Students made reflective observations with regard to apparatus and chemicals such as conical flask, test tube, barium Chloride and Sodium Sulphate.
- Some amount (approximately 15ml) of Sodium Sulphate solution was taken in a conical flask and some amount (approximately 5 ml) of barium chloride solution was taken in another test tube. The test tube with barium chloride solution hanged inside the conical flask, and then they predicted what will occur if two solutions are mixed each other. Students formulated abstract concepts; afterwards they verified their prediction by mixing the two solutions (by tilting and swirling the flask).
- Later, students observed the mixed solutions in terms of colour and physical reaction. Students got concrete experience and reflective observations on the entire procedure of demonstration of experiment.

- Based on the observations students formulate abstract concepts and derived inference Also they inferred that the mass (weight) of flask with solution were found to be same before and after chemical reaction.

Date	**: 22.11.11**
Content Chosen	**: Sink and floating of ice Cubes in Water**
Developed Skills	**: Observation Prediction and Inference**
Learning Experience	**: Hands on Experience**

- Concrete learning experience gained by the students by doing the experiment on sinking and floating of ice cubes in water.
- Ice cubes were shown to the students and they observed reflectively; based on their observation they predicted whether the Ice cubes float or sink in water.
- Later they verified their prediction by doing active experimentation by dropping ice cubes into water, and observed the level of water till ice cubes completely melts.
- Based on the observations students derived inferences that ice floats in water and the water level remain same.

Date	**: 24.11.11**
Content Chosen	**: Discovery of Electron CRT**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Multimedia Presentation**

Students gained concrete learning experience in multimedia theatre by watching videos on Cathode ray tube (CRT).

- Videos and photograph on cathode ray tube was shown to the students for getting concrete experience and reflective observations.
- Students reflectively observed the cathode ray tube (CRT) model and its structure. They drawn the diagram of CRT with labelling the parts clearly. Based on the observation and discussion, students formulated abstract concepts and derived inference.

Date	**: 24.11.11**
Content Chosen	**: Properties of Cathode and Anode Rays**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Multimedia Presentation**

- To get concrete experience, videos and photograph on properties of cathode rays was shown to the students in multimedia theatre (Plate _4.5).
- Students reflectively observed videos and photograph on property of cathode rays and anode rays. They observed the similarities and differences between these two rays.

- Based on the observation of properties of cathode and anode rays, students formulated the abstract concepts on, and they discussed about their observations. Also they and drawn the diagram.
- Based on the observations students derived inferences with regard to properties of cathode and anode rays.

Plate_4.5: Students Observing the CRT in Multimedia Theatre

Date	**: 25.11.11**
Content Chosen	**: Static Electricity**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Experience**

- Group wise students engaged in active experimentation on static electricity by keeping the rubbed comb nearby bits of paper (Plate_4.6).
- Students actively done experimentation. They rubbed glass rod (with silk) and brought nearby inflated balloon, and they observed that the balloon was attracted by glass rod.
- By doing active experimentation students got concrete experience and made reflective observation.
- Based on the observations they formulated abstract concepts and derived inferences.

Plate_4.6: Experiment on Static Electricity

Date	**: 25.11.11**
Content Chosen	**: Corrosion (Rusting of iron nails)**
Developed Skills	**: Observation Prediction and Inference**
Learning Experience	**: Hands on Experience**

- Concrete learning experience gained by students by doing experiment on corrosion (i.e. rusting of iron nails),
- Students observed barium chloride chemical, test tube, hot water and cold water which are taken for corrosion experiments.
- They have done active experimentation: three nails were kept in three different test tubes (one nail in each test tube) containing calcium chloride, hot water and cold water respectively.
- By doing active experimentation students got concrete experience and made reflective observation with regard to the corrosion of iron nails.
- Based on the observations, students predicted which are the nails will get corrosion. And they verified their prediction by observing the nails.
- After two days students observed that colour of three nails. Based on the observations, students formulated abstract concepts and inferred that corrosion of iron takes place in presence of oxygen and water.

Date	**: 25.11.11**
Content Chosen	**: Potato Osmoscope**
Developed Skills	**: Observation Prediction and Inference**
Learning Experience	**: Hands on Experience**

- Students have done active experimentation on potato Osmoscope. A narrow hole was made in a peeled out potato and it was filled by sugar solution. The level of sugar solution in the hallow hole was observed by a pin. Bottom surface of the potato made it flat, and it was kept in a beaker containing blue coloured water (level of coloured water lower than potato). Students got concrete experience by doing experimentation and made reflective observation.
- The observed initial level of sugar solution in potato and the experimental setup kept it at rest for some time (10 minutes). Students predicted that, what will occur in the level of sugar solution in potato after sometimes. Their prediction was verified by continuous observations of level of solution.
- After sometimes students observed the final level of sugar solution in the potato, also they observed the change of colour of sugar solution.
- Based on their observations, students formulated abstract concepts and derived inferences.

Date	**: 25.11.11**
Content Chosen	**: Acid Base Test**
Developed Skills	**: Observation Communication Classification Prediction and Inference**
Learning Experience	**: Hands on Experience**

- ❑ Concrete experience gained by the students by doing acid base test experiment.
- ❑ Students observed KOH, NaOH, acetic acid, grapes, lemon juice and tamarind solution. And they predicted, which are the substances having the characteristics' of acids and bases.
- ❑ Student verified prediction by dipped the litmus paper into each substance such as KOH, NaOH, acetic acid, grapes, lemon juice and tamarind solution, and observed the change of colour of litmus paper and the same recorded in the tabular column.
- ❑ After completion of acid base test, students classified the acid and bases substances.
- ❑ Based on the observations, students' formulated abstract concepts, and derived inferences on acid and base.

Date	**: 28.11.11**
Content Chosen	**: Bar diagram and Line graph**
Developed Skills	**: Observation, Communication and Inference**
Learning Experience	**: Hands on Experience**

- ❑ Numerical data on students' height (in cm) with respect to years was displayed for plotting the bar graph, and they made observation reflectively.
- ❑ Students plotted the bar graph for the given data and gained concrete learning experience.
- ❑ Based on observations, they formulated abstract concepts.
- ❑ Similarly numerical data on uniform and non uniform velocity displayed on the board, students observed and drew the correct line graph for the same. Based on the observations, they formulated abstract concepts and derived inferences.

Date	**:28.11.11**
Content Chosen	**: Classification of Animals**
Developed Skills	**: Observation Classification and Inference**
Learning Experience	**: Multimedia Presentation**

- ❑ Concrete learning experience gained by the students in multimedia theatre by watching all animals, insects' photographs in multimedia theatre.

- Students observed different types of animals, insects' photo such as Herbivores, Carnivores, Omnivores, Vertebrates, invertebrates, unicellular organisms, birds, lizards etc.
- By watching the photograph of different animals, students got concrete experience and made observation reflectively.
- After observations, students classified all animals into different categories based on similarities and differences.
- After classification of animals, students formulated abstract concepts and derived inferences on based on animals' habit, habitat, food, presence and absence of vertebrates, etc.

Date	**: 29.11.11**
Content Chosen	**: Pressure exerted by an Object (Brick)**
Developed Skills	**: Measurement Observation Communication Prediction and Inference**
Learning Experience	**: Hands on experience**

- Students have done active experimentation by measuring the length, breadth and width.
- While measuring the brick, students gained concrete experience and made reflective observations. After measurements, they written with measurement unit.
- While measuring the area, students predicted that in which positions pressure of the brick will be more. In order to verify the prediction, students actively experimented.
- Based on the observations, students formulated the abstract concepts and derived inferences.

Date	**: 29.11.11**
Content Chosen	**: Liquid Exerts Pressure**
Developed Skills	**: Observation, Prediction and Inference**
Learning experience	**: Hands on Experience**

- Students gained concrete experience by doing active experiments on liquid pressure (water) and made reflective observations.
- Experiment (1): Students had taken two transparent plastic tubes at equal length and balloon was tied on the bottom of plastic tube. They poured water in both the plastic tubes at different heights and made reflective observation. By doing the experiments, students got concrete experience and reflective observations.
- After completion of experiment they formulated abstract concepts and derived inferences.

- Experiment (2): Students taken a plastic bottle, and made a small hole just above the bottom and fitted a tube. A balloon was fitted at mouth of the tube and the bottle filled with water. Later they observed that the balloon was bulged. By observing the size of balloon, students made abstract concepts and derived inferences.
- Experiment (3): Students taken a plastic bottle and made four holes around it just above the bottom of the bottle (holes are made at the same height from the bottom). The bottle was filled with water, immediately they observed that water forcefully pumped out through the holes. Based on the observations students formulated abstract concepts and derived inferences.
- Experiment (4): Students taken a plastic bottle and made three holes at different heights from top to bottom. Bottle was filled with water, students observed that water falling down from three holes but different speed. Based on the observations, students formulated abstract concepts and derived inferences.

Date	**: 29.11.11**
Content Chosen	**: Homogenous and Heterogeneous Mixture**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Experience**

- Students received concrete experiences by doing active experimentation on preparing homogenous and heterogeneous mixture.
- They prepared homogenous mixture such as salt solution in a beaker, and heterogeneous mixture such as iron fillings sand in another beaker, and both the mixture observed reflectively in terms of differences between two substances.
- Based on the observations, students formulated abstract concepts and derived inference on homogenous and heterogeneous mixture.

Date	**: 30.11.11**
Content Chosen	**: Pressure depends up on Density of Liquid**
Developed Skills	**: Observation, Prediction and Inference**
Learning Experience	**: Hands on Experience**

- Students received concrete experience by doing active experiment on pressure depends up on the density of liquid.
- Students have taken some amount of water (approximately 200 ml) in one beaker and equal amount of castor oil taken in another beaker. Reflectively observed both the liquid in terms of amount and density. Based on their observations, students made prediction that which will be the heavier (beaker with water or beaker with castor oil).

- Students verified their prediction by holding the beaker with water in one hand. Similarly, holds another beaker with castor oil in another hand. By doing active experimentation, students got concrete experience. Then they observed (Feel) the heavier liquids.
- Based on observations students formulated abstract concepts and derived inferences that pressure depends on density of a liquid.

Date	**: 30.11.11**
Content Chosen	**: Air Exerts Pressure**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Experience**

- In order to get concrete experience, students have done active experimentation on air pressure and made reflective observations.
- They pipette out 20 ml of water from a beaker and closed the pipette mouth (top) by keeping a finger on it. They slowly removed the finger, and noticed that the water comes out. By doing active experimentation, students got concrete experience, made reflective observations.
- Based on the observations students formulated abstract concepts and derived inferences that atmospheric air exerts pressure on water.
- Similarly, students have active experimentation with the help of ink filler and pumped out by pressing the ink filler again. Based on the observation, they inferred that air exerts pressure.

Date	**: 30.11.11**
Content Chosen	**: Magnetic Force (Non Contact Forces)**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Experience**

- Concrete experience gained by the students by doing active experimentation on magnetic force of attraction.
- Two bar magnets kept each other. First, South Pole of one bar magnet kept nearer to South Pole of another magnet. They observed that the magnets repel each other.
- Similarly North Pole of one magnet brought nearer to the north pole of another magnet. They observed that the magnets repel each other.
- Finally, South Pole of one bar magnet was brought nearer to the north pole of another bar magnet; they observed that force of attraction between
- From the above observations, students made abstract concepts and derived inferences.

Date	**: 30.11.11**
Content Chosen	**: Observation of Chemicals**
Developed Skill	**: Observation**
Learning Experience	**: Hands on Experience**

- Student gained concrete experience in laboratory by observing the chemicals.

- ❑ They made reflective observations on colour, appearance, smell, nature and texture of given chemicals.
- ❑ Based on the observation, students formulated abstract concepts and derived inferences.

Date	**: 02.12.11**
Content Chosen	**: Percentage of Hydrogen Ions**
Developed Skills	**: Observation Communication and Inference**
Learning Experience	**: Hands on Experience**

- ❑ Students received concrete experience by doing active experimentation on to test the percentage of hydrogen irons in the given chemicals.
- ❑ Following chemicals such as phenolphthalein solution, Hydro Chloric acid, Methylene orange, acetic acid, sodium hydroxide and water were given to students.
- ❑ Students made reflective observation on colour, nature of substances, appearance, and texture of the given chemical substances.
- ❑ Then they done active experimentation by testing the percentage of hydrogen irons in each chemical substance by using PH paper. By doing hands on experience, students got concrete experience and made reflective observation. Their observations noted in the tabular column.
- ❑ After completion of percentage of hydrogen irons test, students formulated the abstract concepts and derived inference.

Date	**: 02.12.11**
Content Chosen	**: Symbols of Different Electric Components**
Developed Skills	**: Observation and Communication**
Learning Experience	**: Group Activity**

- ❑ Symbol of different electric component corresponding to the function displayed on the board.
- ❑ Students reflectively observed the same and noted down in the tabular column. Based on the observation, they formulated abstract concepts and derived inferences.

Date	**: 09.12.11**
Content Chosen	**: Simple and Parallel Circuits**
Developed Skills	**: Observation, Communication and Inference**
Learning Experience	**: Hands on Experience**

- ❑ Working model of simple circuit, series circuit and parallel circuits' provided to the students for active experimentation. Students gained concrete learning experience by doing experiments.
- ❑ First, they reflectively observed the connections between the wires, bulbs and batteries in three circuits. They observed the differences between three circuits. Students drawn the diagram of circuits and labelled clearly.

- Students have done active experimentation by connecting wires between bulb and batteries in three circuits separately, and gained concrete experiences. Based on the observations of three circuits, students formulated abstract concepts and derived inferences.

Date	**:**	**09.12.11**
Content Chosen	**:**	**Good Conductors and Poor Conductors**
Developed Skills	**:**	**Observation Prediction Classification and Inference**
Learning Experience	**:**	**Hands on Experience**

- Students gained concrete experience by doing active experimentation on good conductors and poor conductors.
- The following materials/substances such as Common salt solution, dilute Hydro Chloric acid (HCl), lime juice and petrol were kept for reflective observations. Students observed and predicted which are the materials/substances conduct electricity, and do not conduct electricity.
- Students verified their prediction by doing active experimentation. They connected one end of the wires with LED bulb and another end of the wire was dipped into beaker containing salt solution, then they observed that the LED bulb was glowing. Likewise students verified their prediction in other solutions such as dilute Hydro Chloric acid, lime juice and petrol. After verification, students classified materials and substances into good and poor conductors.
- Based on the observations, they formulated concepts and derived inferences with regard to good conductors and poor conductors.

Date	**: 09.12.11**
Content Chosen	**: Types of Charges**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Learning**

- Students gained concrete experience by doing following experimentation actively with regard to types of electric charges.
- First, they rubbed inflated balloon with wool and brought near the bits of paper. They observed that paper bits attracted towards balloon. Based on the observations, students' formulated abstract concepts and derived inference.
- Secondly, two plastic straws were rubbed with wool and they brought nearby each other, students observed both the straws repelled each other. Based on observations they made abstract concepts and derived inferences.
- Thirdly, two glass rods were rubbed with silk and they brought nearby each other, students observed that both the glass rod repelled. Based on observations they made abstract concepts and derived inferences.

- Fourth, two plastic rods (straw) was rubbed with wool and they brought nearby each other, students observed that both the plastic rod repelled each other. Based on observations, they made abstract concepts and derived inferences.
- Fifth, a plastic rod was rubbed with wool and a glass rod was rubbed with silk, both were brought nearby each other, they observed that plastic rod and glass rod attracted each other. Based on observations they made abstract concepts and derived inferences.

Date	**: 09.12.11**
Content Chosen	**: Expansion of Solids on Heat**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Experience**

Students actively performed Ball and Ring Experiment through which they got concrete experience.

- They placed a small metal spherical ball over the ring and observed that the metal bob freely entered into the ring. Afterwards students heated the same metal bob and placed over the ring, they observed that the bob did not enter into the ring.
- While doing active experimentation on ball and ring experiment students got concrete experience, also reflectively observed the difference in the ball before and after heating, based on the observations students formulated concepts and derived inferences.

Date	**: 09.12.11**
Content Chosen	**: Expansion of Gases on Heat**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Demonstration**

Students gained concrete experience by watching demonstration on experiment on expansion of Gases on Heat.

- A balloon was fixed on a mouth of the small empty bottle and it was kept in a beaker containing hot water. Students observed that the balloon blows up (inflattened) immediately. Soon after the bottle with balloon taken back from hot water and kept it on rest for some time. Students observed that the balloon gets flattened (contracts). By observing the experiment they got concrete experiences and made reflective observations.
- Based on their observations they formulate abstract concepts and derived inferences.

Date	**: 09.12.11**
Content Chosen	**: Conduction and Convection of Heat**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Experience**

- ❑ Students got concrete experience by doing experiments on transfer of heat in solids (Conduction) and transfer of heat in liquids (Convection).
- ❑ Students have done active experimentation on conduction of heat in Solid: They supplied heat in one end of the thin iron rod, after sometimes students sensed (Observation by touching) the heat in another end of the same rod.
- ❑ While doing active experiments, students gained concrete experience, and reflectively observed the raise of heat in another end of the same iron rod.
- ❑ Based on the observations, they formulated abstract concepts and derived inferences on conduction of heat.
- ❑ Students engaged in another experiment on transfer of heat in liquids. They have taken hot water in a beaker (1 litre) and added few amount of potassium permanganate pellets, and observed the scattering of potassium permanganate ($KMnO_4$) particles inside the water; also they observed that change of colour of water due to dispersion of $KMnO_4$ particles.
- ❑ Based on the observations they formulated abstract concepts and derived inferences on convection of heat in liquid.

Date	**: 12.12.11and 13.12.11**
Content Chosen	**: Electroplating**
Developed Skills	**: Observation classification and Inference**
Learning Experience	**: Group Discussion**

Concrete learning experience gained by the students by observing the outer surface of wrist watch, steel spoon, crews, covering jewellery are shining, polished and polished.

- ❑ Students observed the outer layer of different metals, and they formulated abstract concepts and inferences.

Date	**: 02.01.12**
Content Chosen	**: Lightning and Thunder formation**
Developed Skills	**: Observation Prediction and Inference**
Learning Experience	**: Multimedia Presentation**

- ❑ Concrete learning experience gained by students by watching videos and photographs on formation of lightning and thunder in multimedia theatre.
- ❑ Before watching videos, they recalled thunder and lightning which they saw in rainy season, and then they predicted what the cause of lightning and thunder.

- To verify the prediction, students reflectively observed the massive positive and negative charges in the clouds and their movements. Also students observed the collision of two opposite charges and discharges of electric charges during lightening.
- Based on their observations and previous experiences, they formulated abstract concepts on formation of thunder and lightning, and derived inferences.

Date	**: 05.01.12**
Content Chosen	**: Thermal Expansion in our daily life**
Developed Skills	**: Observation, Prediction and Inference**
Learning Experience	**: Multimedia Presentation**

- Concrete experience received in multimedia theatre by watching photograph on thermal expansion in our daily life.
- Students observed the small gap in the railway lines; telephone wires and electric wires sag between two poles in photograph. Also they recalled the direct observations on railway lines gap; telephone wires and electric wires sag between two poles.
- After observing the photograph and personal observations, students made prediction that over a period of time what may occur in the railway lines gap; and what may be the reason for telephone and electric wires sag between two poles.
- Based on the observations, they formulated abstract concepts and derived inferences.

Date	**: 05.01.12**
Content Chosen	**: Laws of Reflection of light**
Developed Skills	**:Observation Communication Measurement and Inference**
Learning Experience	**: Hands on experience**

Students got concrete experience by doing active experimentation on reflection of light.

- A plane mirror vertically placed on the white paper and focused a beam of light towards plane mirror.
- After passing a light on mirror, students observed reflected, students drawn the diagram of incident ray, reflected ray and normal.

- Then they measured the angles between incident ray and normal, angle between reflected ray and normal with the help of protractor.
- Based on the observations and measurement, students formulated abstract concepts and inference on laws of reflection of light.

Date	**: 05.01.12**
Content Chosen	**: Multiple Reflections**
Developed Skills	**: Observation Communication Prediction and Inference**
Learning Experience	**: Hands on Experience**

- Students actively performed the experiment on multiple reflections and they got concrete experience.
- An object (pen) was placed in front two mirrors and they observed number of images in the mirrors. Based on the number of images, they predicted what will be the number of images in the following angles such as 30^0, 45^0, 60^0, 90^0 and 120^0. Students verified their prediction by doing active experimentation.
- Similarly, students made kaleidoscope and observed multiple number of images. They got concrete experiences by doing active experimentation, and made reflective observations of number of images in different angles.
- Based on observations, they formulated abstract concepts and derived inference.

Date	**: 06:01:12**
Content Chosen	**: Refraction**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Experience**

- Students received concrete experience by doing experiment on refraction.
- A pencil was partially immersed in a beaker containing water, and a coin also was placed in the same beaker for observations.
- Students observed that part of the pencil immersed in the water appears to be bent and larger in size. Also they observed the coin in the water appears to be closer and bigger.
- Based on their observations, students' formulated abstract concepts and derived inferences.

Date	**: 06.01.12**
Developed Skills	**: Observation Classification and Inference**
Content Chosen	**: Refraction**
Learning Experience	**: Hands on Experience**

- Students actively engaged in experiment on refraction i.e. deviation of light rays when it passes from denser medium (water) to rarer medium (air).
- A beam of red light was focussed towards beaker containing water; they observed the change of deviation of red light from water to air.
- Based on observations of deviation of red light, students' formulated abstract concepts and derived inferences.

Date	**: 06.01.12**
Content Chosen	**: Dispersion of Light**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Experience**

- Students gained concrete learning experience by doing prism experimentation on dispersion of light.
- Students observed seven colours in the prism.
- Based on the observations, students formulated abstract concepts and derived inferences.

Date	**: 09.01.12**
Content Chosen	**: Sound Produced by Vibration of body**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Experience, and Group Discussion**

- Students gained concrete experience by doing active experimentation on sound produced by vibration of body or objects.
- They Just they plucked free end of the scale, and observed (hear) the sound which is produced by vibrations of scale.
- Similarly the picture of birds sound, loud speaker, and aeroplane, car, firing crackers, beating drums, and barking dogs were shown to the students' for observations. Based on the observation, students derived inferences.

Date	**: 10.01.12**
Content Chosen	**: Sound Produced by different objects**
Developed Skills	**: Observations and Inference**
Learning Experiences	**: Hands on Experience**

- Students tapped the following objects such as metal plate, a plastic bottle, a sheet of paper, a wooden block, a cloth for observing different types of sound.
- By doing above activity, students got concrete experience, and listens the different types of sound produced by different objects.
- Based on the observations they derived inferences.

Date	**: 13.01.12**
Content Chosen	**: Sound Produced by Tuning Forks**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Hands on Experience**

- Concrete experiences gained by the students by doing active experimentation on vibrating tuning forks.
- A different type tuning forks was given for active experimentation, students strikes the prongs one by one and observed the different sounds produced by prongs of tuning forks.
- Students differentiated the different types of sound produced by different types of tuning forks.
- Based on the observations students formulated abstract concepts and derived inferences.

Date	**: 19.01.12**
Content Chosen	**: Observations of Preserved Animal Specimens**
Developed Skills	**: Observation and Classification**
Learning Experience: Hand on Experience	

- Students gained concrete experience in the laboratory by observing the preserved animal Specimens such as snake, shark, snail, star fish, ascaris worm (male and female), prawn, frog, cockroach and earthworm.
- By observing the preserved animals' specimens, students got concrete experience and made reflective observations. Students observed animals' body shape, colour, structure, legs, antenna, tentacles, arms, body segments and other bodily features and characteristics, and the same discussed with other students.
- After observations, they have classified the given animal specimens based on similarities and differences, and formulated abstract concepts.

Date	**: 20.01.12**
Content Chosen	**: Pollution and its Types**
Developed Skills	**: Observation Classification and Inference**
Learning Experience	**: Multimedia Presentation**

- Students received concrete experience in multimedia theatre by watching videos and photograph on different types pollutants.
- They watched videos and pictures on air pollutants, water pollutants, and land pollutants. And they made reflective observations on following pollutants such as industrial emissions, vehicles smoke, power stations and

aeroplanes, burning of fuels, fertilizers, pesticides, sewage waters, factory wastes, plastics, wastes cloths, industrial waste water, animal waste, fertilizers, pesticides, sewage water, and waste water by washing vehicles, bathing human and animals.

- Based on the observations of different types of pollutants, they classified all the pollutants into air pollutants, water pollutants and land pollutants, and formulated abstract and derived inferences.

Date	**: 20.01.12**
Content Chosen	**: Percentage of air in atmosphere**
Developed Skill	**: Communication and Inference**
Learning Experience	**: Group Discussion**

- Numerical data on percentage of air in atmosphere was displayed on the blackboard; students observed and draw pie chart for the same.
- Based on the observations of pie chart, students derived inferences.

Date	**: 23.01.12**
Content Chosen	**: Sinking and floating Experiment**
Developed Skills	**: Observation and Prediction**
Learning Experience	**: Demonstration**

- Students observed the objects and substances such rubber, pencil, and vegetables such as tomato, potato, and brinjal dropped into water and kerosene. By observing the objects and substances, students predicted which are the objects may sink or float in water and kerosene.
- Students verified the prediction by active experimentation and gained concrete experience on sinking and floating experiments. The following objects such as rubber, pencil, and vegetables such as tomato, potato, and brinjal dropped into water and kerosene, and observed the floating and sinking. Based on observations, students classified floating and sinking objects and substances.

Date	**: 24.01.12**
Concept	**: Extraction of Petroleum**
Developed Skills	**: Observation and Inference**
Learning Experience	**: Multimedia Presentation**

- Students watching videos and pictures on extraction of Petroleum in multimedia theatre and gained concrete experience.
- They observed the different fractions of petroleum such as petroleum gas, petrol, kerosene, diesel, lubricating oil, fuel oil, paraffin wax and bitumen by fractional distillation in fractionating columns. Based on the observations, they derived inferences.

Date : 27.01.12
Content Chosen : Wind Mill and Solar Energy
Developed Skills : Observation and Inference
Learning Experience: Multimedia Presentation

- ❑ Concrete experience gained by students by watching videos on wind mill, solar energy, solar cookers, solar water heaters and solar cells (Alternative Sources of Energy) in multimedia theatre for getting.
- ❑ Students observed wind mill, solar energy, based on observations, they formulated abstract concepts and inference.

Date : 31.01.12
Content Chosen : Afforestation and deforestation
Developed Skills : Observation and Inference
Learning Experience: Multimedia Presentation

- ❑ Concrete experience was provided to the students in multimedia theatre by showing the videos on Afforestation and deforestation. They observed and derived inferences on Afforestation, and deforestation.

Date : 02.02.12
Content Chosen : Flora and Fauna in India
Developed Skills : Observation Communication and Inference
Learning Experience : Group Discussion

- ❑ Numerical data on flora (plants) and fauna (animals) was displayed on the blackboard for reflective observations. Students observed (seeing) the total number of species of flora and fauna. Based on numerical data, they drawn bar diagram and pie diagram. Then they formulated abstract concepts and derived inferences.

Date : 03.02.12
Content Chosen : Organisms and its habitat
Developed Skills : Observation Classification Communication and Inferences
Learning Experience : Field Visit to Gene Pool Garden

- ❑ Students gained concrete experiences by visiting the field (garden), and made reflective observation on plants and animals (Plate_4.7).They observed and classified the plant kingdom based on similarities and differences. They drew the diagram of classification of plants as shown in the display board.
- ❑ Students reflectively observed the food chain between different animals, and drawn the same. Also observed the display board of global warming and green house effect. They drawn the green house effect and global warming diagram. Based on the observations of diagram of food chain, global warming and green house effect students derived inferences.

- Students observed the metamorphosis (Different stages) of butterflies; they observed shape, body parts, and nature of body of preserved insects and animals in museum.
- Students gained concrete experience and made reflective observation on fern house. They observed the leaflets, stem, roots, flowers and spores of pteridophytes. They also observed aquatic plants, insects and fish in water tank. And they classified into the organisms into animals, plants, and insects.

Date	**: 11.02.12**
Content Chosen	**: Vermiculture (Earthworm Culture)**
Developed Skills	**: Observations**
Learning Experience	**: Field Visit**

- Students got concrete experience in vermiculture farm, and observed the type of soil, bedding, food and feeding, eggs of earthworm, and structure of earth worm in the field (Plate_4.7). During observation they drew the diagram of earthworm and derived inferences.

Plate_4.7: Field Visit

Students communicating through diagram in Gene pool Garden

Students observing the Vermiculture farm

4.4 Status of Basic Science Process Skills After Intervention Programme

After intervention programme, the collected data with the help of open ended questionnaire was analysed both item wise and skill wise by using rubrics. The item wise and skill wise analysed data is presented from table 4.8 to 4.13.

Table_4.8

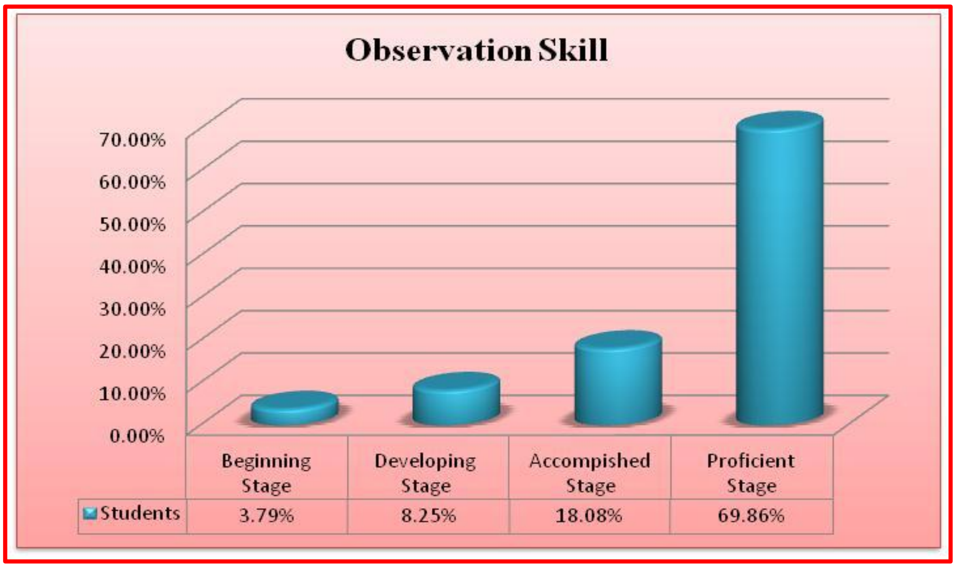
Performance of Students in Observational Skill

Item No	Parameters of Observation Skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplished Stage	% of Students in Proficient Stage
1.	Similarities and difference between plant cell and animal cell	(01) 3.57%	-	(06) 21.42%	(21) 75%
2.	Observation of pencil and coin in a glass with water	(01) 3.57%	(02) 7.14%	(04) 14.28%	(21) 75%
3.	Observation of flame of lighted candle	(01) 3.57%	(02) 7.14%	(04) 14.28%	(21) 75%
4.	Similarities and differences between parenchyma and sclerenchyma cell	(01) 7.14%	(03) 10.71%	(06) 21.42%	(17) 60.71%
5.	Differences between ginger and potato	-	(03) 10.71%	(06) 21.42%	(19) 67.85%
6.	Observation of decayed bread	(01) 3.57%	(06) 21.42%	(03) 10.71%	(18) 64.28%
7.	Observing the mercury level in the thermometer kept in water.	(02) 7.14%	(02) 7.14%	(03) 10.71%	(06) 75%
8.	Observation of preserved Centipede specimen.	(01) 3.57%	(06) 21.42%	(04) 14.28%	(17) 60.71%
9.	Observation of Chemicals	(01)3.57%	(02) 7.14%	(03) 10.71%	(22) 78.57%
10.	Listens audio on Saturn planet.	(01)3.57%	(01)3.57%	(07)25%	(19)67.85%
11.	Observation of Human Blood tissue slide in microscope.	(01) 3.57%	(03) 10.71%	(10) 35.71%	(14) 50%
12.	Observation of differences between aquatic succession	(01) 3.57%	(01) 3.57%	(04) 14.28%	(22) 78.57%
13.	Observation of sand.	(01) 3.57%	(01) 3.57%	(07) 25%	(19) 67.85%
14.	Observing the picture of beaker, trough, and the scale.	(01) 3.57%	-	(05) 17.85%	(22) 78%
15.	Observation of preserved spider specimen.	(01) 3.57%	(04) 14.28%	(06) 21.42%	(17) 60.71%
16.	Observation of a plant (real specimen)	(01) 3.57%	(01) 3.57%	(03) 10.71%	(23) 82.14%
Overall Performance		3.79%	8.25%	18.08%	69.86%

From the table_4.8, it can be observed that most of the students' observation skill was in proficient stage wherein students skilfully employed the sense organs to observe the colour, appearance, texture of chemicals, and also very skilfully used the instruments such as microscope and magnifying lens to notice the fine details of plant and animal specimens. The following graph_4.7 shows students overall performance in observation skill.

Graph_4.7

Overall Performance of Students in Observation Skill



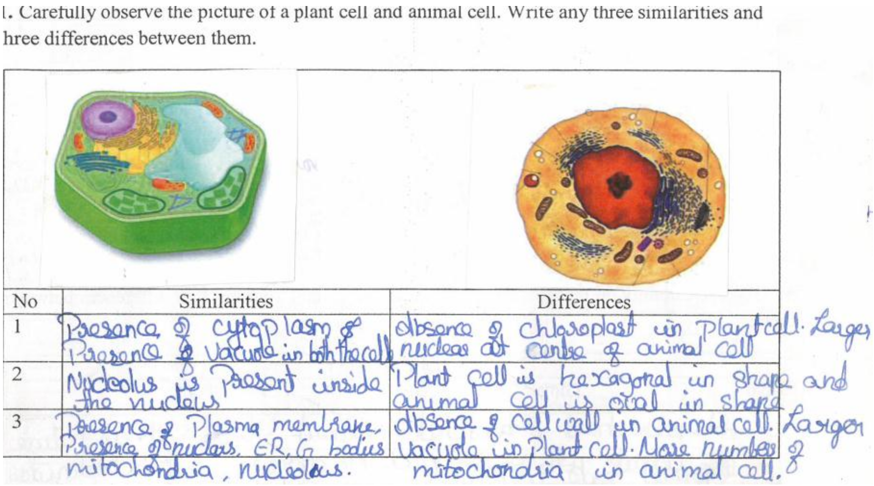
From the graph 4.7, it can be seen that

- ❑ 3.79% students' observation skill was in beginning stage wherein students' could not observe the similarities and differences between similar pictures. They did not use magnifying lens to observe the fine details of plant and animal specimens, also microscope was not skilfully operated for observing the fine details slides. Colour, smell, texture and appearance of chemicals were not observed.
- ❑ 8.25% students' observation skill was in developing stage wherein students observed very few similarities and differences between the similar pictures. They observed few morphological characteristics and fine details of plants and animals specimens. Texture, appearance, colour of chemical noticed to some extent correctly. Magnifying lens and microscope were used somewhat effectively during observations.

- 10.71% students' observations skill was in accomplished stage wherein students observed most of the similarities and differences between similar pictures. Most of the morphological characteristics of plants and animals specimens were noticed. Students almost effectively used Microscope and magnifying to observe the slides and specimens.
- 82.14% students' observation skill was proficient stage wherein students correctly observed all similarities and differences between similar pictures (Picture_4.6). They noticed fine details of the given specimens of plants and animals. Skilfully used the magnifying lens and microscope to observe of slides and specimens. Skilfully employed all the sensory organs to observe the colour, smell, texture, appearance of chemicals.

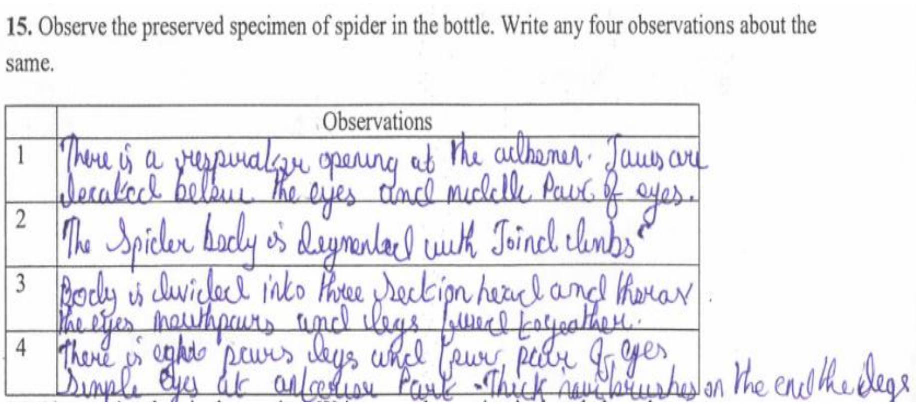
From the above observation, it can be said that most of the students attained proficient stage in observation skill in the post intervention programme.

Picture_4.6: Observation Skill



1. Carefully observe the picture of a plant cell and animal cell. Write any three similarities and three differences between them.

No	Similarities	Differences
1	Presence of cytoplasm & Presence of vacuole in both the cell	absence of chloroplast in plant cell. Larger nuclear at centre of animal cell
2	Nucleolus is present inside the nucleus	Plant cell is hexagonal in shape and animal cell is oval in shape
3	Presence of Plasma membrane, Presence of nucleus, ER, G bodies mitochondria, nucleolus.	absence of cell wall in animal cell. Larger vacuole in plant cell. More number of mitochondria in animal cell.



15. Observe the preserved specimen of spider in the bottle. Write any four observations about the same.

	Observations
1	There is a respiratory opening at the abdomen. Jaws are located below the eyes and middle part of eyes.
2	The Spider body is segmented with joined limbs
3	Body is divided into three section head and thorax the eyes mouthparts and legs fused together.
4	There is eight pairs legs and four pair of eyes simple eyes at anterior part. Thick hair brushes on the end the legs

Table_4.9

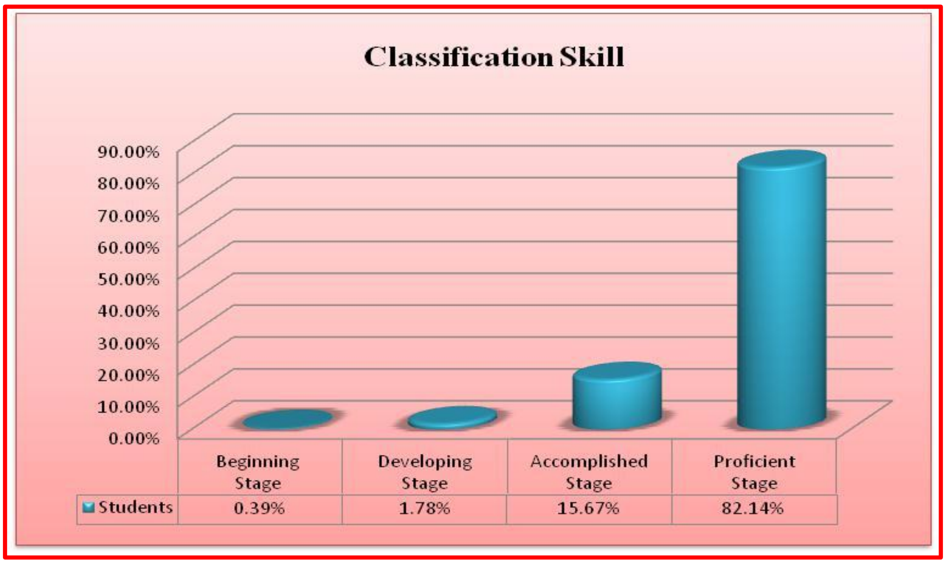
Performance of Students in Classification Skill

Item No	Parameters of Classification Skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplished Stage	% of Students in Proficient Stage
1.	Classifying the things into conductors and insulators	-	(01) 3.57%	-	(27) 96.42%
2.	Classifying into magnetic and non magnetic substances	-	(01) 3.57%	-	(27) 96.42%
3.	Classifying the animals based on common attributes.	(01) 3.57%	(01) 3.57%	57.14%	(10) 35.71%
4.	Classifying the things into solids liquids and gases.	(01) 3.57%	(01) 3.57%	-	(26) 92.85%
5.	Classify into pure, impure, opaque, and transparent substances.	-	(01) 3.57%	(04) 14.28%	(23) 82.14%
6.	Classifying the materials into metals and non metals	-	-	(02) 7.14%	(26) 92.85%
7.	Classification: hydrophytes, mesophytes and xerophytes.	-	(01) 3.57%	(01) 3.57%	(26) 92.85%
8.	Classifying the animals into aerial, arboreal and cave animals.	-	(01) 3.57%	(05) 14.28%	(23) 82.14%
9.	Classifying the materials/ substances into transparent, translucent & opaque.	-	-	(09) 32.14%	(19) 67.85%
10.	Classifying the animals into herbivores, carnivores and omnivores	-	-	(02) 7.14%	(26) 92.85%
11.	Classification: soluble, insoluble and slightly soluble substances in water.	-	-	(02) 7.14%	(26) 92.85%
12.	Classifying the organisms into unicellular and multicellular.	-	-	(05) 17.85%	(23) 82.14%
13.	Classifying the organisms into reptiles and amphibians.	-	-	(05) 17.85%	(23) 82.14%
14.	Classifying the animals into vertebrates and invertebrates.	-	-	(03) 10.71%	(25) 89.28%
15.	Acids and bases classification.	-	-	(05) 17.85%	(23) 82.14%
16.	Classification: first order, second order and third order levers.	-	(03) 10.71%	(14) 50%	(11) 39.28%
17.	Classifying the food materials into pulses and cereals	-	-	(14) 14.28%	(24) 85.71%
18	Classifying the fruits into dry and fleshy fruits	-	-	(02) 7.14%	(26) 92.85%
Overall Performance		0.39%	1.78%	15.67%	82.14%

It can be observed from the table_8.9, most of the students' classification skill was in proficient. Students correctly classified all the things, materials, organisms based on the similarities and differences. They were proficient in classifying the things, objects and substances. Students overall performance in classification skill is shown in the graph_4.8.

Graph_4.8

Overall Performance of Students in Classification Skill



From the graph 4.8, it can be observed that

- 0.39% student's classification skill was in beginning stage. 1.78% student's classification skill was in developing stage wherein very few things, materials and organisms' were correctly classified based on similarities and differences. However most of the things, materials and organisms could not classify by the students.
- 15.67% students' classification skill was in accomplished stage wherein most of the things, materials, substances were classified into conductors' insulators, metals and non metals, solids liquids gas, opaque transparent translucent materials based on similarities and differences. Similarly, students classified most of the plants and animals into unicellular, multicellular, herbivores carnivores', birds' insects etc, however few things, substances, organisms incorrectly classified by the students.
- 82.14% students' classification skill was in proficient wherein all the things, materials, substances such as conductors' insulators, metals non metals, solids liquids and gas, opaque transparent translucent materials, plants and animals were classified correctly based on similarities and differences (Picture_4.7).

From the above observations, it can be inferred that most of the students attained proficient stage in classification skill which indicates that the intervention programme enhanced students' classification skill.

Picture_4.7: Classification Skill

Conductors	Insulators
copper, wire, Aluminium foil, scale steel, Iron nails, Earth	Mica, Leather object, wood, plastic bangles, charcoal, Thermocole, plastic Ebomite, Graphite, Glass, silicon Graphite

	Classified into	Name of the organisms	Reasons
1	Insects	House fly, ant, cockroach Butterfly	They are very small and their life span is very short
2	Herbivores	cow, elephant, sheep	They are plants eating animals, they do not eat fish
3	Invertibrate	House fly, ant, cockroach butterfly.	They do not have backbone
4	carnivores	Eagle	Because they eat flesh only
5	Birds	sparrow, eagle	These are the animals living in the air (Aerial animal
6	vertibrates	cat, elephant, cow, sheep eagle sparrow	These are the animals having backbone
7	Domestic animals	elephant, cow, cat, Sheep	They will live in a house.

Table_4.10

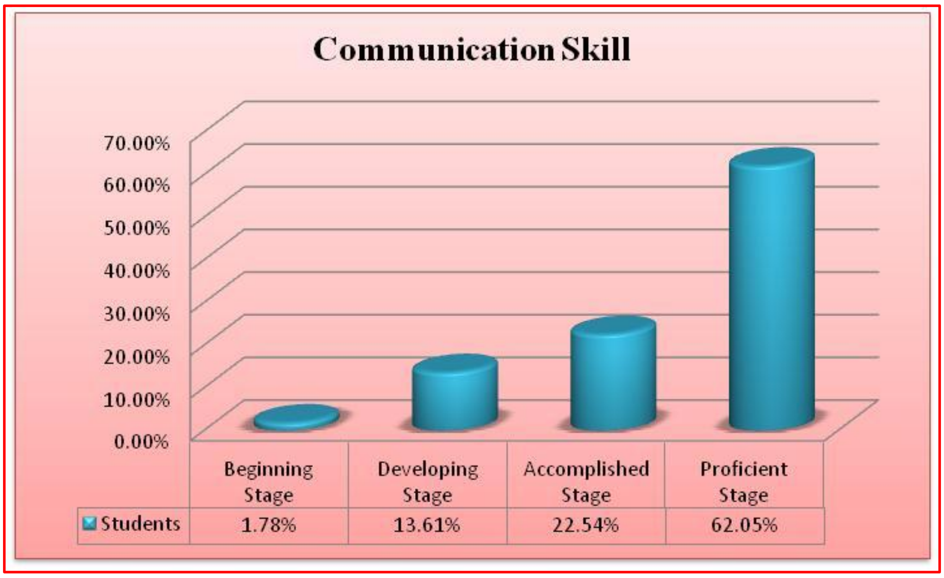
Performance of Students in Communication Skill

Item No	Parameters of Communication Skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplis hed Stage	% of Students in Proficient Stage
1.	Draw a line graph for velocity versus time	-	(01) 3.57%	(04) 14.28%	(23) 82.14%
2.	Draw a bar graph for data on requirements of calorific value for adults (male and female) with respect to their age.	-	(06) 21.42%	(16) 57.14%	(06) 21.42%
3.	Write name of the different electric component corresponding to the symbols	-	(01) 3.57%	(04) 14.28%	(23) 82.14%
4.	Draw arrow mark to show flow of energy between different organisms.	-	(01) 3.57%	(04) 14.28%	(23) 82.14%
5.	Draw the arrow mark to show the food web among the different organisms.	-	(01) 3.57%	(04) 14.28%	(23) 82.14%
6.	Draw line graph for uniform speed verses time.	-	(01) 3.57%	(04) 14.28%	(23) 82.14%
7.	Draw line graph for non uniform speed verses time.	-	(08) 28.57%	(09) 32.14%	(11) 39.28%
8.	Write name of elements corresponding to Pictorial symbols.	-	(02) 7.14%	-	(26) 92.85%
9.	Draw pie chart to show percentage of atmospheric gases.	(03) 10.71%	(12) 42.85%	(06) 21.42%	(07) 25%
10.	Draw the diagram of Human heart.	(01) 3.57%	(04) 14.28%	(08) 28.57%	(15) 53.57%
11.	Write name of the elements corresponding to symbol.	(01) 3.57%	-	(14) 14.28%	(23) 82.14%
12.	Draw the diagram of Human brain.	(01) 3.57%	(10) 35.71%	(11) 39.28%	(06) 21.42%
13.	Write different stages of metamorphosis of insects.	(01) 3.57%	(04) 14.28%	(07) 25%	(16) 57.14%
14.	Draw the tabular column to show life span of different organisms.	(01) 3.47%	(01) 3.57%	(07) 25%	(19) 67.85%
15.	Write chemical formula for chemical reaction.	-	(06) 21.42%	(11) 39.28%	(11) 39.28%
16.	Write steps of tissue culture technique.	-	(03) 10.71%	(11) 7.14%	(23) 82.14%
	Overall Performance	1.78%	13.61%	22.54%	62.05%

From the table_4.10, it can be observed that most of the students' communication skill was in proficient stage wherein students skilfully communicated through line graph, bar diagram, pie chart, symbols, tables, flow chart and diagram. Students overall performance of communication skill is shown in the graph_ 4.9.

Graph_4.9

Overall Performance of Students in Communication Skill

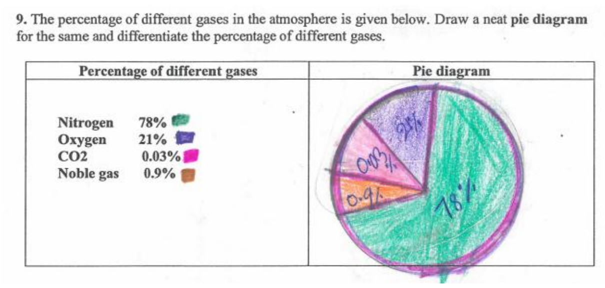


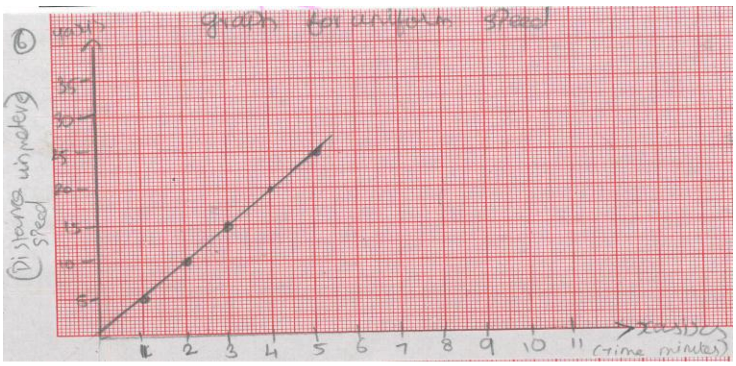
The following observations can be made from the graph 4.9

- ❑ 1.78% student's communication skill was in beginning stage wherein students incorrectly drew the pie chart for the given data. They could not communicate through diagram, symbols of element and tabular column.
- ❑ 13.61% students' communication skill was in developing stage wherein somewhat correctly drew the diagram. X axis and Y axis variable written correctly in the graph but the plotted line graph and bar graph was incorrect. Drew incomplete tabular column and entered data incompletely. Very few symbols written correctly.
- ❑ 22.54% students' communication skill was in accomplished stage wherein almost correctly drew pie chart, line graph and bar graph. However they committed some sort of error. Almost correctly and completely drew tabular column and displayed most of the data. They were skilful in drawing diagram. Most of the chemical elements symbols written correctly.
- ❑ 62.05% students' communication skill was in proficient stage wherein students effectively communicated through bar graph, line graph, pie chart (Picture_4.8). They skilfully drew diagram, effectively communicated through symbols, and tabular column.

From the above observations, it can be inferred that most of the students attained proficiency in communication skill.

Picture_4.8: Communication Skill





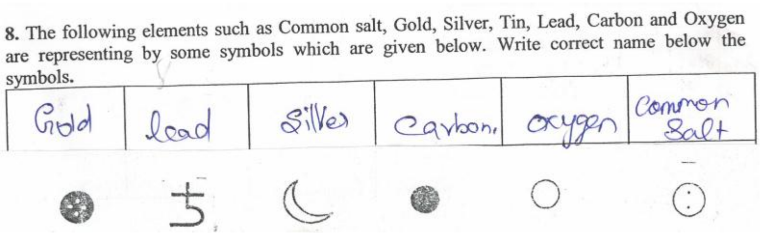


Table_4.11

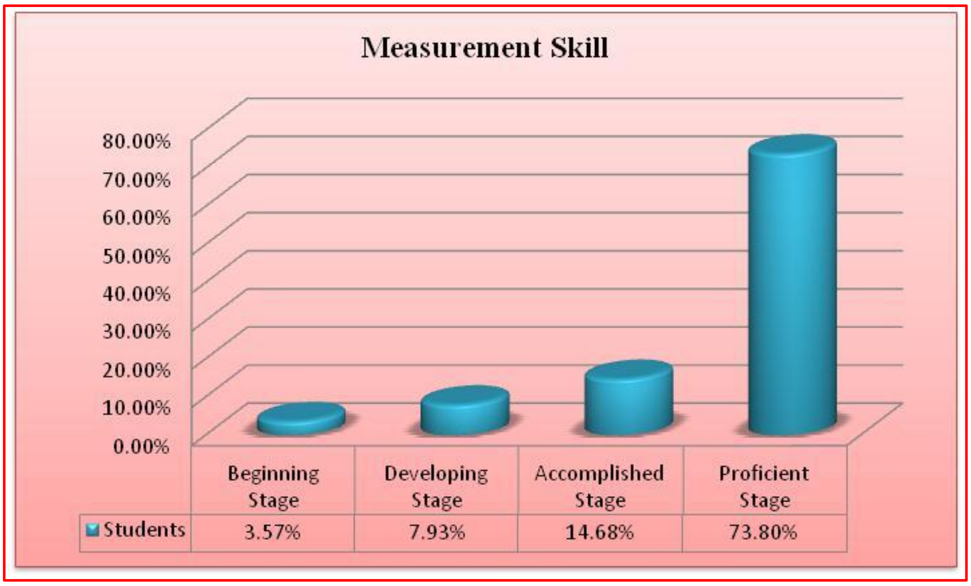
Performance of Students in Measurement Skill

Item No	Parameters of Measurement Skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplished Stage	% of Students in Proficient Stage
1.	Measure the length, breadth of rectangle diagram.	(01) 3.57%	-	-	(27) 96.42%
2.	Measure the base and height of the triangle diagram.	-	-	(01) 3.57%	(27) 96.42%
3.	Measurement of exact amount of water in measuring cylinder.	-	(03) 10.71%	(11) 39%	(14) 50%
4.	Measure the length, breadth and height of the cuboids diagram.		(01) 3.57%	(01) 3.57%	(26) 92.85%
5.	Measure the angles between two joined lines of two diagrams.	-	-	(02) 7.14%	(26) 92.85%
6.	Measure the total area of leaf (irregular object).	(02) 7.14%	(13) 46.42%	(13) 46.42%	-
7.	Measure the mass of the object using pointer balance	(01) 3.57%	-	-	(27) 96.42%
8.	Measure the temperature of hot water and cold water.	(01) 3.57%	(05) 17.85%	(06) 21.42%	(16) 57.14%
9.	Measure the length, breadth and height of the table.	(03) 10.71%	(03) 10.71%	(09) 32.14%	(13) 46.42%
10.	Determine the volume of irregular object (Stone) by displacement of water.	(02) 7.14%	(01) 3.57%	(04) 14.28%	(21) 75%
11.	Measure the length of the pendulum and time period for one oscillation.	(01) 3.57%	-	(10) 10.71%	(24) 85.71%
12.	Measure the length and breadth of cloth.	-	(02) 14.28%	(01) 3.57%	(24) 82.14%
13.	Measuring $KMnO_4$ solution in graduated beaker.	-	(04) 14.28%	(09) 32.14%	(15) 53.57%
14.	Pipette out 20 ml of water from beaker.	-	(02) 7.14%	(08) 28.57%	(18) 64.28%
15.	Measure width of book and calculate thickness of one page.	(01)3.57%	(03) 10.71%	-	(24) 85.71%
16	Measure the temperature of classroom in Celsius and Fahrenheit scale.	-	-	(04) 14.28%	(24) 85.71%
17.	Measure the length of curved line diagram by using thread	(06) 21.42%	(03) 10.71%	-	(19) 67.85
18.	Measure the length, breadth of post card	-	-	(01)3.57%	(27) 96.42%
Overall Performance		(01)3.57%	7.93%	14.68%	73.80%

By observing the table_4.11, it can be seen that most of the students' measurement skill was in proficient stage wherein students correctly measured the length, breadth, height, volume, area, temperature. Students used the measurement devices very skilfully during measurement. Students overall performance in measurement skill is shown in the graph_4.10.

Graph_4.10

Overall Performance of Students in Measurement Skill



The following observations can be made from the graph 4.10

- ❑ 3.57% students' measurement skill was in beginning stage wherein students followed the measurement procedure incorrectly while measuring the length, breadth, height, temperature, weight, volume. Students did not use the measurement devices skilfully.
- ❑ 7.93% students' measurement skill was in developing stage wherein students somewhat correctly followed the measurement procedure while measuring the length, breadth, height, volume, area of irregular object (leaf), temperature. However the measurement was not precise because they committed some error while measuring the objects and liquids.
- ❑ 14.68% students' measurement skill was in accomplished stage wherein students almost correctly followed measurement procedure while measuring the length, breadth, volume, weight, temperature, area. However they committed some sort of minor mistakes. For example, volume of water and $KMnO_4$ solution was skilfully measured by the students with the help of

pipette and burette but they could not notice the lower or higher meniscus; similarly height and breadth of the table was measured correctly but length of the table was measured incorrectly. Students skilfully used measurement devices but committed minor error during measurement.

- 73.80% students measurement skill was in proficient stage wherein students measured the length, breadth, height, mass (weight) of the object, temperature, volume, total area of irregular object (leaf) very accurately. Very skilfully students used the measurement devices while measuring the objects or liquids. After completion of measurement, it was written with appropriate measurement units.

From the above observations it can be inferred that most of the students' proficient in measurement skill.

Plate_4.8: Measurement Skill

Measuring the volume of water	*Measuring temperature of water*
	

Table_4.12

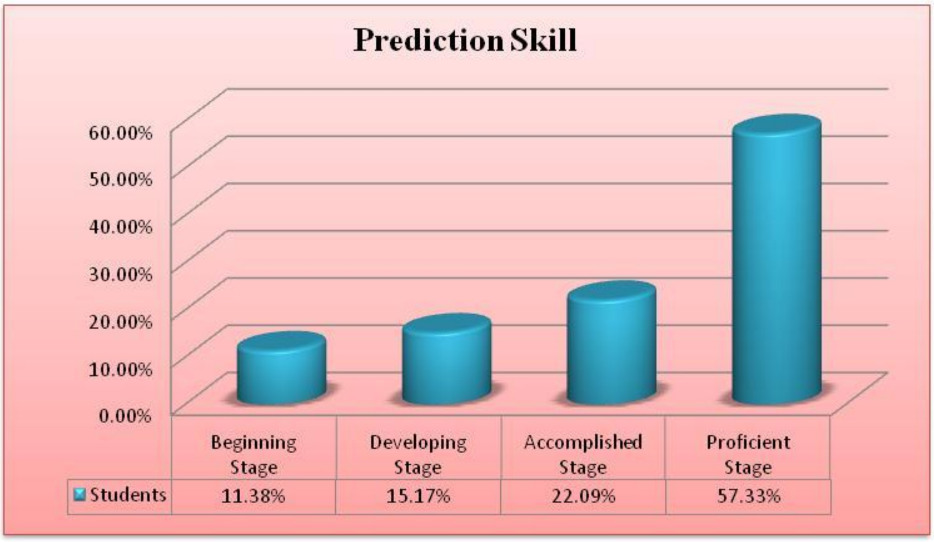
Performance of Students in Prediction Skill

Item No	Parameters of Prediction skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplished Stage	% of Students in Proficient Stage
1.	Predict: Ice cubes float or sink of in water. Change of water level.	-	(02) 7.14%	(01) 3.57%	(25) 89.28%
2.	Predict: time taken for different number of oscillations at different length.	-	(02) 7.14%	(18) 64.28%	(08) 28.57%
3.	Predict: floatation of different liquids in water.	(01) 3.57%	(03) 10.71%	(10) 35.71%	(14) 50%
4.	Predict: egg float or sink of (i) in water, (ii) salt solution and (iii) vinegar.	-	(01) 3.57%	(03) 10.71%	(24) 85.71%
5.	Predict the angle between two joined plane mirrors.	-	-	(01) 3.57%	(27) 96.42%
6.	Predict floating & sinking of objects in water & kerosene.	-	(02) 7.14%	(08) 28.57%	(18) 64.28%
7.	Predict the temp of hot water and cold water.	(06) 21.42%	(07) 25%	(14) 50%	(01) 3.57%
8.	Predict fast dissolving in water.	(01) 3.57%	(05) 17.85%	(06) 21.42%	(16) 57.14%
9.	Prediction on miscibility and immiscibility of liquids in water.	-	(01) 3.57%	(09) 32.14%	(18) 64.28%
10.	Prediction on osmosis (thistle funnel experiment).	-	(03) 10.71%	(05) 17.85%	(20) 71.42%
11.	Predict: seed germinate fastly in soil + fertilizer or soil + manure.	(08) 28.57%	(03) 10.71%	(01) 3.57%	(16) 57.14%
12,	Predict: ice fastly melting in cold water or salt solution or Sugar solution.	(15) 53.57%	(11) 39.28%	(02) 7.14%	-
13.	Predict temperature of water decrease fastly in aluminium, brass, and mud pot, plastic and steel vessels.	(18) 64.28%	(03) 10.71%	(05) 17.85%	(02) 7.14%
14.	Predict: evaporation fastly takes place in petrol or water.	(01) 3.57%	(04) 14.28%	(07) 21.42%	(17) 60.71%
15.	Predict: going to be rain or not	(02) 7.14%	(14) 46.42%	(06) 21.42%	(07) 25%
16.	Predict: a leaf with worm.	(01) 3.57%	(07) 25%	(03) 10.71%	(17) 60.71%
	Overall Performance	11.38%	15.17%	22.09%	57.33%

From the table_4.12, it can be seen that most of the students' prediction skill was in proficient stage wherein they correctly predicted the future events and occurrences based on observation and experiences. Students overall performance in prediction skill is shown in the graph_4.11.

Graph_4.11

Overall Performance of Students in Prediction Skill



Following observation can be made from the graph 4.11

- ❑ 11.38% students' prediction skill was in beginning stage wherein students' prediction was incorrect. They could not predict the events correctly based on observation and experiences. Also they unable to give correct reasons for their prediction.
- ❑ 15.17% students' prediction skill was in developing stage wherein some of the predictions were correct but they could not give correct reasons for their prediction. For example students correctly predicted that ice cubes float in water but given reason for the prediction was incorrect.
- ❑ 22.09% students' prediction skill was in accomplished stage wherein students correctly predicted the forthcoming events and occurrences based on the observation and previous experience but the given reasons was partially correct but not completely correct.
- ❑ 57.33% students' prediction skill was in proficient stage wherein they correctly predicted the future events and occurrences based on observations and past experiences, and also they given correct reasons for their prediction (Picture_4.9).

Based on the above observations, it can be said that most of the students attained proficient stage in the post intervention programme.

Picture_4.9: Prediction Skill

1. The ice cubes and water in a beaker are kept for experiment. Predict your answer for the following questions.

a) Write your prediction; if ice cubes dropped in to the beaker containing water, will it float or sink? Write reasons for your answer.

Prediction	Reason(s) for prediction
I predict Ice cubes will...float	Because...of Pressure of air bubbles ice cubes will float density of ice cubes is lesser than water.

b) Predict, whether water level will increase or decrease or remain same during melting of ice cubes. Write reasons for your answer.

Prediction	Reason(s) for prediction
I predict water level will ...be Remain Same...during melting of ice.	Because...Volume will not change during the Physical change. and during physical change the total mass of the matter remain Same (Law of conservation

S.No	Liquid floatation from top to bottom	Reason(s) for prediction
1.	Kerosene	Because...Always heavier density liquid sink at the bottom and lighter density liquid floats up her the is most high density liquid and is least density liquid therefore floats up and sunkdown
2.	Diesel	
3.	water	
4.	Castor oil	
5.	honey	

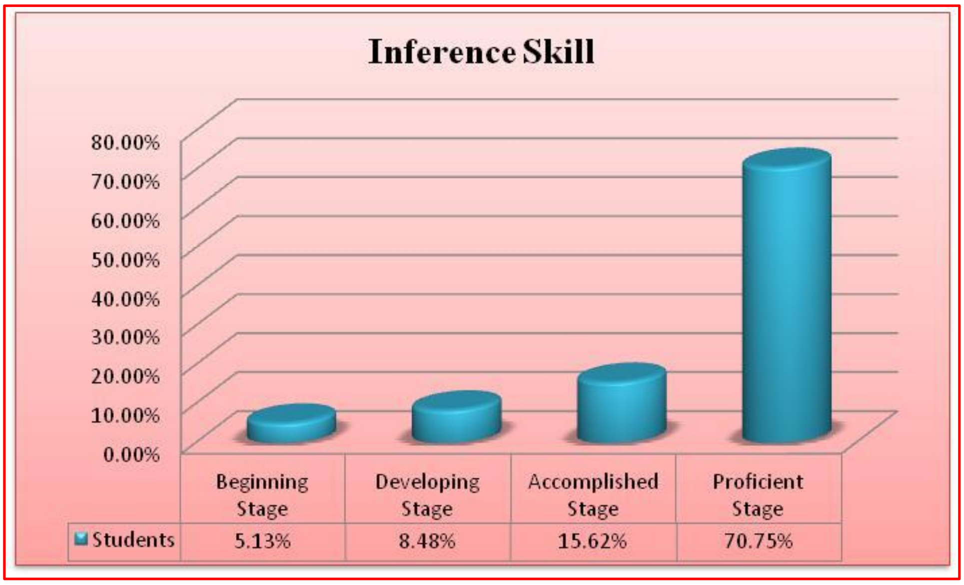
Table_4.13
Performance of Students in Inference Skill

Item No	Parameters of Inference Skill	% of Students in Beginning Stage	% of Students in Developing Stage	% of Students in Accomplished Stage	% of Students in Proficient Stage
1.	Inference based on observation of melting of ice cubes in thistle funnel with thermometer.	(01) 3.57%	(01) 3.57%	(04) 14.28%	(22) 78.57%
2.	Inference based on observation of photosynthesis picture.	(01) 3.57%	-	(02) 7.14%	(25) 89.28%
3.	Inference on Soluble and insoluble substances in water.	(01) 3.57%	(02) 7.14%	(04) 14.28%	(21) 75%
4.	Inference based on observation of acid and base test.	(01) 3.57%	(01) 3.57%	(06) 21.42%	(20) 71.42%
5.	Inference on transfer of heat in solid (iron rod experiment)	(01) 3.57%	(02) 7.14%	(03) 10.71%	(22) 78.57%
6.	Inference on solar eclipse and lunar eclipse	(01) 3.57%	(02) 7.14%	(02) 7.14%	(23) 82.14%
7.	Inference on observation of transpiration picture	(01) 3.57%	(01) 3.57%	(08) 28.57%	(18) 64.28%
8.	Inference based on floatation of different liquids such as kerosene, castor oil, diesel and honey in water.	(01) 3.57%	(01) 3.57%	(04) 14.28%	(22) 78.57%
9.	Inference based on absorption of heat by empty inflated balloon & inflated balloon with water when both are brought over the lighted candle.	(02) 7.14%	(02) 7.14%	(04) 14.28%	(20) 71.42%
10.	Inference based on Simple pendulum experiment.	(01) 3.57%	(03) 10.71%	(07) 25%	(17) 60.71%
11.	Inference based on observations of water droplets on outer surface of the steel tumbler.	(02) 7.14%	(02) 7.14%	(05) 17.85 %	(19) 67.85%
12.	Inference based on observation of experiment on neutralisation of acid base test.	(02) 7.14%	(05) 17.85%	(06) 21.42%	(15) 53.57%
13.	Inference based on change of states of matter (Melting, Sublimation and Vaporisation)	(01) 3.57%	(07) 25%	(08) 28.57%	(12) 42.85%
14.	Inference on anomalous expansion of water in pond	(03) 10.71%	(03) 10.71%	(02) 7.14%	(20) 71.42%
15.	Inference on food Chain between different organisms	(01) 3.57%	(03) 10.71%	(03) 10.71%	(21) 75%
16.	Inference on different types of levers.	(03) 10.71%	(03) 10.71%	(02) 7.14%	(20) 71.42%
	Overall Performance	5.13%	8.48%	15.62%	70.75%

From the table no_4.13, it can be observed that most of the students' inference skill was in proficient stage. Students correctly derived inferences based on observations of picture and experiments. The following graph_4.12 shows students overall performance in inference skill.

Graph_4.12

Overall Performance of Students in Inference Skill



Following observation cab ne made from the graph 4.12

- 5.13% students' inference skill was in beginning stage wherein students could not derive inferences correctly based on observations of pictures and experiments, instead they had written observations of pictures and experiments. This indicates that they were unable to differentiate between inferences and observations.
- 8.48% students' inference skill was in developing stage wherein students somewhat correctly derived few inferences based on observations of pictures, experiments, demonstration and video. However more observation was written. Students somewhat able to differentiate observations and inferences.
- 15.62% students' inference skill was in accomplished stage wherein students correctly derived most of the inferences based on observations of pictures and experiments. However few inference(s) they could not derive, instead they written observations.

- ❑ 70.75% students' inference skill was in proficient stage wherein students' correctly and completely derived inference(s) based on observations of experiments, demonstration, pictures and videos (Picture_4.10). Students enhanced their inference skill, and they able to differentiate observations and inferences.

From the above observations, it can be seen that most of the students attained proficient in inference skill in the post intervention programme.

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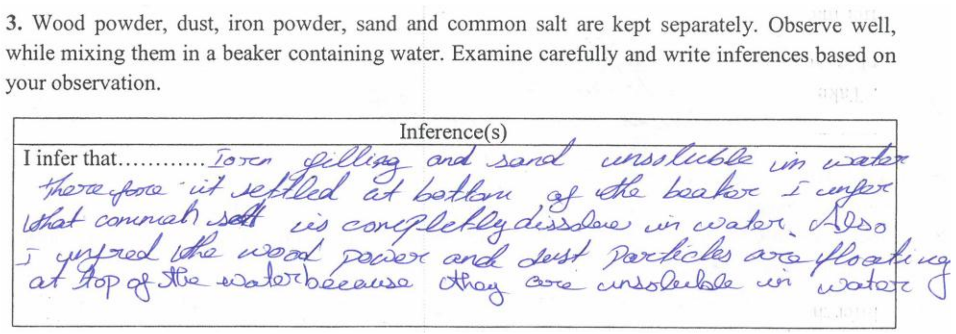
Picture_4.10: Inference Skill

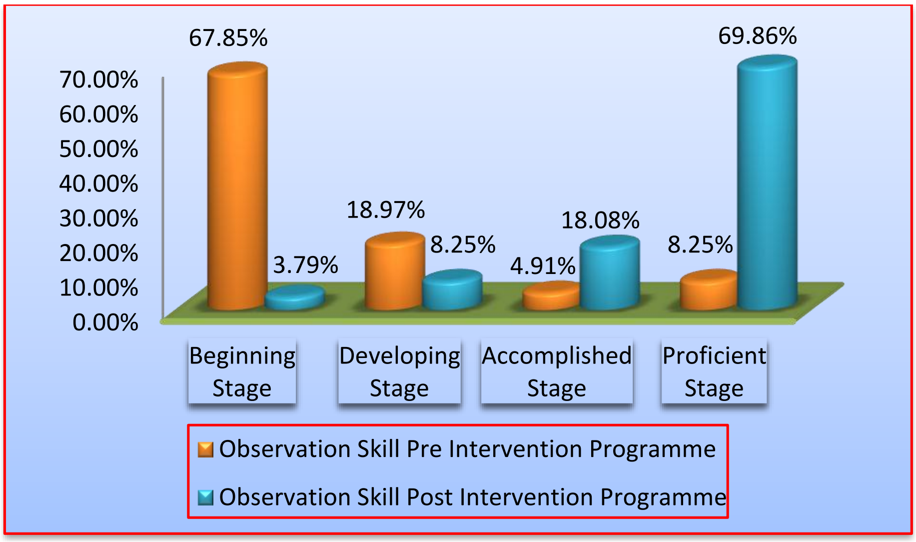


3. Wood powder, dust, iron powder, sand and common salt are kept separately. Observe well, while mixing them in a beaker containing water. Examine carefully and write inferences based on your observation.

Inference(s)
I infer that............Iron filling and sand unsoluble in water therefore it settled at bottom of the beaker I infer that common salt is completely dissolve in water. Also I infered the wood power and dust particles are floating at top of the water because they are unsoluble in water

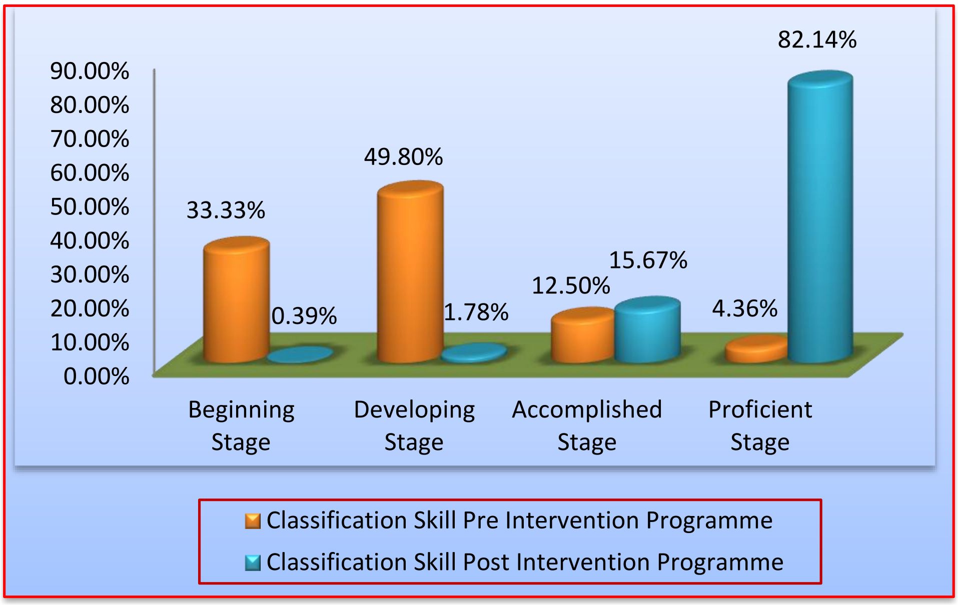
4.5 Difference between Pre and Post Intervention Programme with regard to acquisition of BSPS

Graph_4.13: Observation Skill



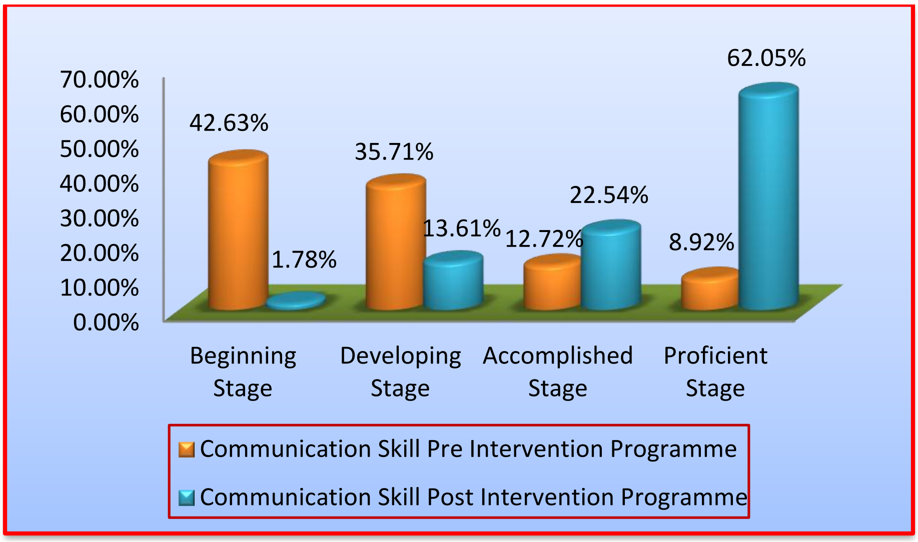
It can be observed from the graph_4.13 that before implementation of intervention programme, 8.25% students were proficient in observations skill. After implementation of intervention programme, 69.86% students were proficient in observation skill. It indicates that experiential learning intervention programme enhanced students' observation skill proficiency in terms of observing the similarities and differences between similar picture, noticing the fine detail of specimens, observing the colour, texture, appearance and smell of chemicals. Students skilfully used their sense organs and instruments such as microscope and magnifying lens during observations. From this it can be concluded that experiential learning intervention programme effective for acquisition of observation skill.

Graph_4.14: Classification Skill



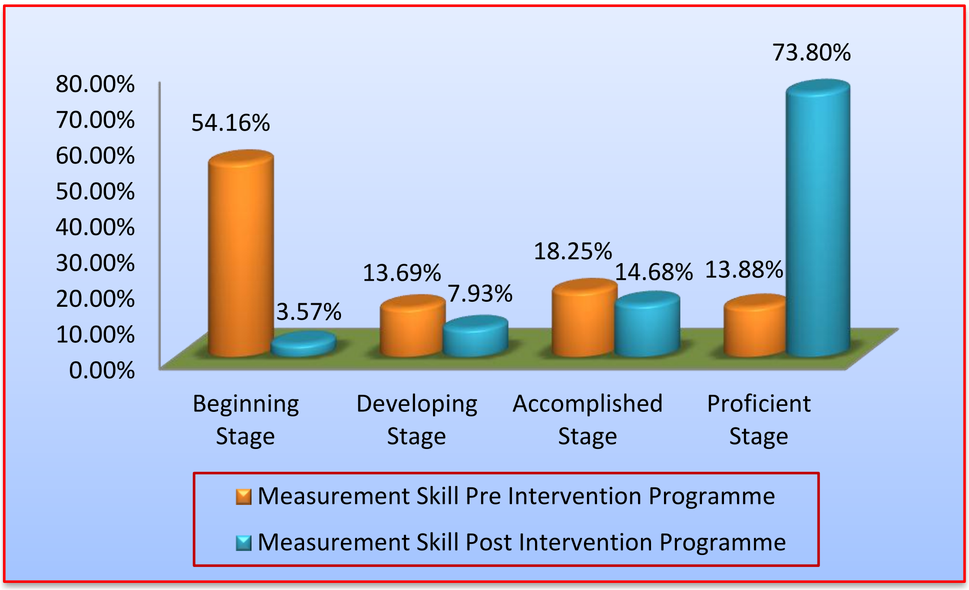
It can be observed from the graph_4.14 that, before intervention programme 4.36% students' classification skill was in proficient. After intervention programme 82.14% students were proficient in classification skill wherein they classified organisms, things, materials, substances based on similarities and differences, presence and absence of certain characteristics. It indicates that the experiential learning intervention enhanced students' skill of classification.

Graph_4.15: Communication Skill



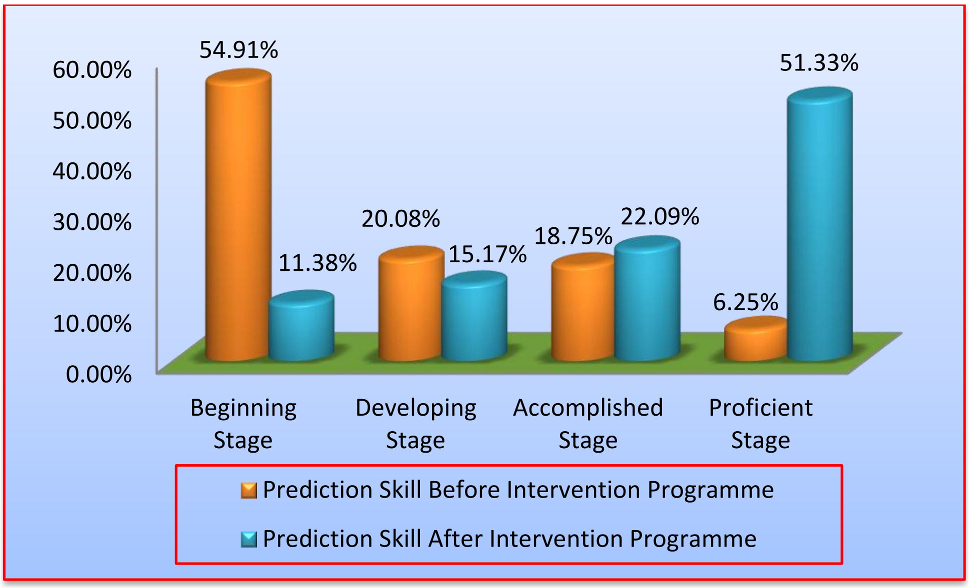
From the graph 4.15, it can be seen that before implementation of intervention programme 8.92% students communication skill was proficient whereas after implementation of intervention programme 62.05% students communication skill was proficient in terms of plotting line graph, bar graph, pie chart, tables, writing symbols, drawing diagrams. It indicates that the intervention programme improved students' communication skills. From this it can be inferred that the programme is effective in terms of acquisition of communication skills.

Graph_4.16: Measurement Skill



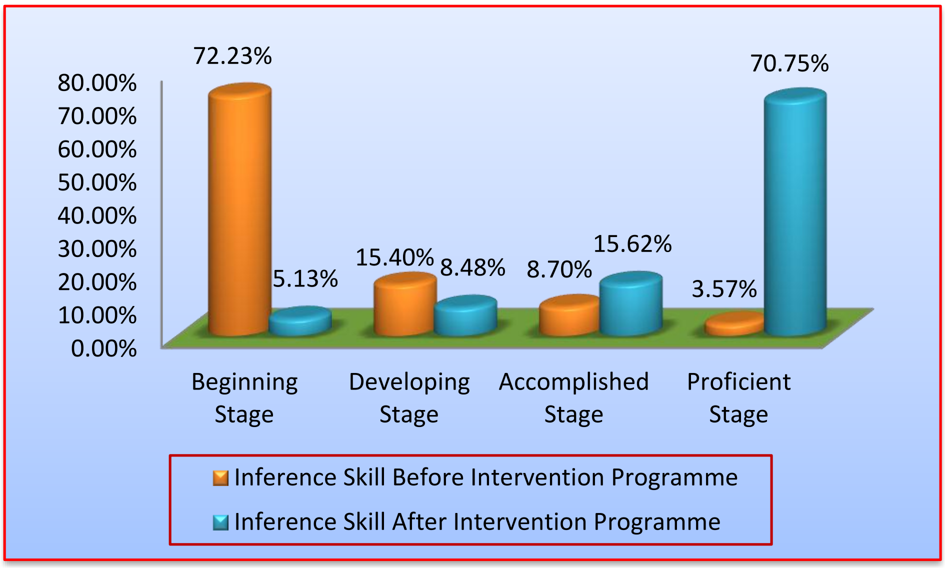
It can be observed from the graph_4.16 that before intervention programme 13.88% students' measurement skill was proficient. After implementation of intervention programme 73.80% students proficient in measuring the length, breadth, height, weight, temperature, area of irregular objects (leaf) and volume of liquids. Also students skilfully used measurement devices during measurement and written appropriate measurement units. From this observation it can be inferred that through experiential learning intervention programme, students improved in measurement skill.

Graph_4.17: Prediction Skill



It can be observed from the graph_4.17, that before intervention programme 6.25% students were proficient in prediction skill whereas after intervention programme 51.33% students' attained proficiency in prediction skill. It indicates that experiential learning intervention programme enhanced the prediction skill among the students.

Graph_4.18: Inference Skill



From the graph_4.18, it can be observed that before intervention programme 3.57% students' were proficient in inference skill whereas after intervention programme 70.75% students were proficient in inference skill in terms of deriving inferences based on observation pictures, experiments and videos. It indicates that the intervention programme enhanced students skill of inference. From this it can be said that the programme is effective.

In a nutshell, from the above observations in the light of acquisition basic Science process skills, it can be inferred that the students' proficiency was more (82.14%) in classification skill, and less students (51.33%) proficient stage in prediction skill.

4.6 Effectiveness of Intervention Programme for acquisition BSPS

In order to see the effectiveness of experiential learning intervention programme in terms of acquisition of basic science process skills (BSPS), the following null hypotheses were proposed for each basic process skill such as observation, classification, communication, measurement, prediction and inference. The proposed null hypothesis was tested by Chi square (χ^2) (2*4 Contingency) at 0.05 level of significance at 3 degree of freedom. The null hypotheses and followed by Chi square (χ^2) table value are as follows

Ho1: 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.

Table_4.14

Testing of null hypothesis No.1 (Observation Skill)

Item No	Chi Square (χ^2) Calculated Value	Chi Square (χ^2) Table Value	Degree of Freedom
1	41.12	7.82	3
2	30.00	7.82	3
3	44.86	7.82	3
4	45.18	7.82	3
5	33.57	7.82	3
6	43.16	7.82	3
7	40.58	7.82	3
8	44.44	7.82	3
9	41.80	7.82	3
10	43.04	7.82	3
11	45.12	7.82	3
12	37.68	7.82	3
13	45.03	7.82	3

The table 4.14 shows that the calculated Chi square (χ^2) value of observation skill from the item numbers 1 to 13 is in between 30.00 to 45.18 at 3 degree of freedom which are greater than Chi square table value (7.82) at 0.05 level of significance. Hence, the proposed null hypothesis is rejected and it can be interpreted that the difference in the observed and expected frequencies between pre and post intervention programme is highly significant in terms of acquisition of observation skill. The significant difference is that the observed frequency in post intervention programme is high which indicates that the intervention programme enhanced skill of observation. From this, it can be inferred that the intervention programme is effective in terms of acquisition of observation skill.

Ho 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.

Table_4.15

Testing of null hypothesis No.2 (Classification Skill)

Item No	Chi Square (χ^2)Calculated Value	Chi Square(χ^2) Table Value	Degree of Freedom
14.	38.52	7.82	3
15.	37.60	7.82	3
16.	42.50	7.82	3
17.	44.63	7.82	3
18.	48.72	7.82	3
19.	41.86	7.82	3
20.	45.32	7.82	3
21.	48.46	7.82	3
22.	42.20	7.82	3
23.	42.54	7.82	3
24.	45.32	7.82	3
25.	44.80	7.82	3
26.	40.72	7.82	3
27.	48.94	7.82	3
28.	48.34	7.82	3
29.	40.30	7.82	3
30.	48.48	7.82	3

The table 4.15 shows that the computed Chi square (χ^2) value of classification skill from the item numbers 14 to 30 is in between 37.60 to 48.48 at 3 degree of freedom which are higher than the Chi square (χ^2) table value of 7.82 at 0.05 level of significance. Hence the null hypothesis is rejected and it can be stated that there is significant difference in the observed and expected frequencies between pre and post Intervention Programme in terms of acquisition of classification skill. The significant difference is that the observed frequency in post intervention programme found to be high which indicates that the intervention programme improved students' classification Skill. Therefore the programme is found to be effective.

Ho 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.

Table_4.16

Testing of null hypothesis No.3 (Communication Skill)

Item No	Chi Square(χ^2) Calculated Value	Chi Square χ^2) Table Value	Degree of Freedom
31.	45.72	7.82	3
32.	36.48	7.82	3
33.	33.62	7.82	3
34.	45.44	7.82	3
35.	47.28	7.82	3
36.	43.24	7.82	3
37.	43.52	7.82	3
38.	49.20	7.82	3
39.	36.59	7.82	3
40.	46.44	7.82	3
41.	43.52	7.82	3
42.	44.58	7.82	3
43.	42.04	7.82	3
44.	48.42	7.82	3

The table 4.16 shows that the computed Chi square (χ^2) value of communication skill from the item numbers 31 to 44 is in between 33.62 to 49.20 at 3 degree of freedom which are greater than Chi square (χ^2) table value of 7.82 at 0.05 level of significance. Therefore the formulated null hypothesis is rejected. It is further interpreted that there is significant difference in the observed and expected frequencies between pre and post intervention programme in terms of acquisition of communication skill. The significant difference is that the observed frequency in post intervention programme comparatively higher than the pre intervention programme which indicates that the Intervention Programme facilitated the students' to acquire communication skills. Hence, the programme is said to be effective in terms of acquisition of communication skill.

Ho 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.

Table_4.17

Testing of null hypothesis No.4 (Measurement Skill)

Item No	Chi Square (χ^2) Calculated Value	Chi Square (χ^2) Table Value	Degree of Freedom
45.	47.36	7.82	3
46.	48.48	7.82	3
47.	48.52	7.82	3
48.	49.52	7.82	3
49.	49.51	7.82	3
50.	48.04	7.82	3
51.	45.28	7.82	3
52.	48.60	7.82	3
53.	48.52	7.82	3
54.	44.30	7.82	3

The table 4.17 shows that The computed chi square (χ^2) value for measurement skills from the item numbers 45 to 54 is in between 44.30 to 49.51 which are greater than Chi square (χ^2) table value of 7.82 at 0.05 level of significance at 3 degree of freedom (df). Hence the proposed null hypothesis is rejected. It is further interpreted that the difference between observed and expected frequency in pre and post intervention programme is significant. The significant difference is that the observed frequency in post intervention programme is high which indicates that students enhanced measurement skill through intervention programme. From this, it can be inferred that the Experiential Learning Intervention Programme is effective in terms of acquisition of measurement skill.

Ho 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.

Table_4.18

Testing of null hypothesis No.5 (Prediction Skill)

Item No	Chi Square(χ^2) Calculated Value	Chi Square (χ^2) Table Value	Degree of Freedom
55.	47.36	7.82	3
56.	42.78	7.82	3
57.	45.28	7.82	3

The table 4.18 shows that the obtained chi square (χ^2) value for prediction skill from the item numbers 55 to 57 is in between 47.36 to 45.28 which are higher than chi square (χ^2) table value of 7.82 at 0.05 level of significance with 3 degree of freedom. Hence the null hypothesis is rejected, and it was found that the difference between observed and expected frequencies in pre and post intervention programme is highly significant. The difference is that the observed frequency in post intervention programme comparatively higher than pre intervention programme which indicates that the intervention programme improved prediction skill in students. From this it can be concluded that the intervention programme is effective in terms of acquisition of prediction skill.

Ho 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.

Table_4.19

Testing of null hypothesis No.6 (Inference Skill)

Item No	Chi Square (χ^2) Calculated Value	Chi Square (χ^2) Table Value	Degree of Freedom
58.	48.48	7.82	3
59.	45.70	7.82	3
60.	49.56	7.82	3

The table 4.19 shows that, from item number 58, 59 and 60 in Inference skill, the calculated chi square (χ^2) value is in between 48.48 to 49.56 which are greater than of chi square (χ^2) table value of 7.82 at 0.05 level of significance for degree of freedom 3. Hence the proposed null hypothesis is rejected. It is interpreted that there is a significant difference in the observed and expected frequencies between pre and post intervention programme. The significant difference is that the observed frequency in post intervention programme is higher than pre intervention programme which indicates that the intervention programme enhanced inference skill. Therefore, it can be said that the programme is effective.

4.7 Effectiveness of Intervention Programme with respect to BSPS achievement

To see the effectiveness of Experiential Learning Intervention Programme in terms of achievement on basic science process skills, the following null hypothesis was formulated.

Ho 7:There will be no significant difference in the mean scores of pre test and post test with regard to achievement on basic Science process skills in Students of standard VIII

The above null hypothesis was tested by paired sample "t" test to determine whether there is a significant difference between means for one sample at two different times i.e. pre and post intervention Programme. The calculated "t" value was tested with 0.01 level of significance at 27 degree of freedom. The calculated "t" value is shown in the table_4.20.

Table_4.20

Achievement Scores on Science Process Skills

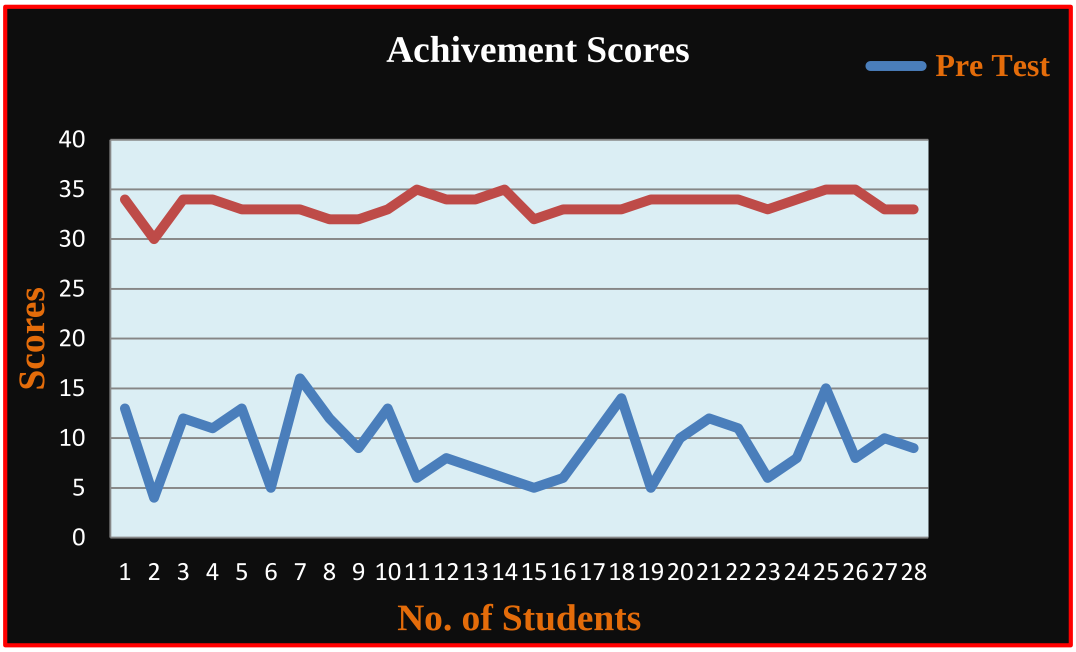
BSPS Test (35 Items)	Mean	S.D	S.E.M	Degree of Freedom	"t" Value
Pre test administered before Intervention Programme	9.42	3.37	0.64	27	35.2671
Post test administered after Intervention Programme	33.33	1.29	0.24	27	

*At 0.01 level of Significance

From the table_4.20 it can be observed that the computed "t" value 35. 2671 is greater than the table value, hence the proposed null hypothesis is rejected and it can be interpreted that the difference in the mean scores of achievement test on basic science process skill is highly significant at 0.01 level of significance with 27 degree of freedom. The difference is that the students' achievement scores on BSPS found to be higher in post intervention than the pre intervention programme. From this, it can be concluded that the intervention programme is effective in terms of achievement in basic science process skills.

Graph_4.19

BSPS achievement Scores in Pre and Post Test



4.8 Triangulation of Data

For the present study, researcher used data triangulation method to validate the accuracy, credibility and trustworthiness of present study findings. According to Norman Denzin (UNAIDS, 2010), data triangulation is one of the type of triangulation of data in which multiple data collected from different sources and can be analysed in a single study. In this study, researcher collected data from teachers, parents, and students through FGD and interview and it was triangulated (figure_4.1). The findings of data triangulation was cross checked and corroborated with findings obtained through other data analysis techniques used in this same study.

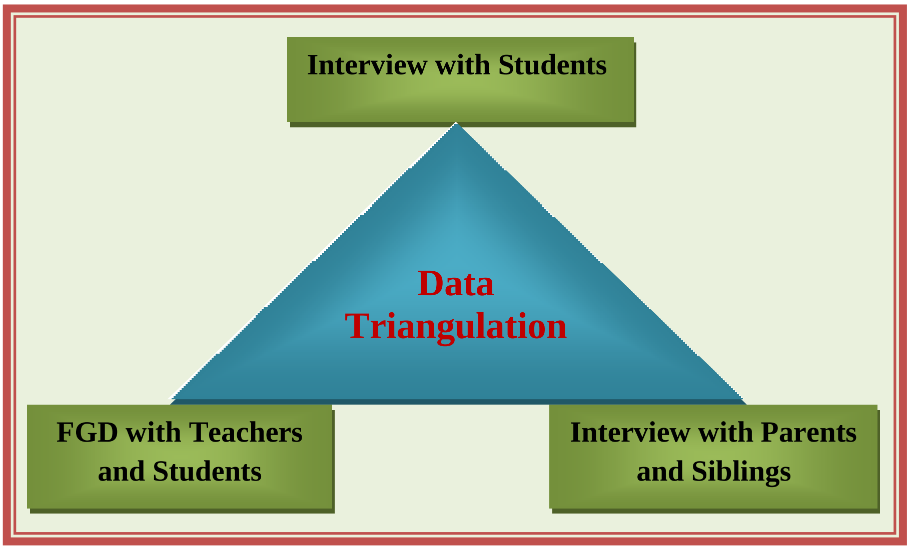
Analysis of Teachers and Students responses: During FGD, Teachers' stated that "Students of standard VIII learnt science through experiential mode wherein they engaged in science experiments and activities by their own and acquired the process skills". Science teaching provided opportunity for the students to handle the apparatus and equipments, materials to measure the length, breadth, volume, and temperature. Through experiential learning, students developed knowledge, skills and interest towards science. Similarly, Students also expressed their feelings that "in the earlier classes we have not done any experiments by our own, very rarely visited multimedia theatre, laboratory but this year in eighth standard (2011-12) we have done experiments by our own, visited to field, multimedia theatre, laboratory and acquired process skills".

Analysis of Parents and Siblings responses: While interviewing with parents and siblings, they stated that students learnt science through direct hands on experiences. During sixth and seventh standards, students were not exposed in practical side of science but in eighth standard students have done science experiments personally, and they shown interest in science. Field visit, multimedia presentation, role play laboratory visit are interesting and concrete learning experiences. Parents suggested that experiential learning method should be continued and it is to be followed in other subjects too.

Analysis of interview with Students: Students stated that “Kolb’s experiential learning intervention programme facilitated to acquire science process skills. Further they stated that the learning experiences included in the programme was very interesting to study and understand the science contents. Also they opined that they acquired process skills which helpful for later stage of education.

In a nut shell, by observing the data triangulation, it can be said that the experiential learning intervention programme facilitates the students to acquire process skills. This triangulation increases the present study accuracy, credibility, trustworthiness of results.

Figure_4.1: Data Triangulation



This chapter deals data analysis and interpretation, the subsequent chapter presents major findings.

CHAPTER V
MAJOR FINDINGS AND DISCUSSION

5.1 Introduction

The major findings were drawn based on the data analysis and interpretation presented in the previous chapter. The findings are presented in this chapter in three sections (i) status of Basic Science Process Skills before intervention programme (ii) acquisition of Basic Science Process Skills during intervention programme (iii) status of Basic Science Process Skills after intervention programme. The three sections of findings are as follows.

5.2 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.
- ❑ **With regard to Observation Skill**
  - ➢ 67.85% students' observation skill was in beginning stage wherein students could not observe the similarities and differences between similar pictures, unable to observe the fine details of plant and animal specimens with the help of magnifying lens. Students did not employ all the sensory organs, and microscope during observations, for example colour of different chemicals was observed but smell, texture, and appearance of chemicals was not noticed by them.
  - ➢ 17.89% students' observations skill was in developing stage wherein students observed very few similarities and differences between similar pictures. The magnifying lens and microscope were skilfully used for noticing very few fine details of specimens such as decayed bread, insects and sand to some extent.

- 4.91% students' observation skill was in accomplished stage wherein students observed most of the similarities and differences, fine details of specimens by employing sensory organs, microscope and hand lens.
- 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.

- **With regard to Classification Skill**
  - 33.33% students' classification skill was in beginning stage wherein students incorrectly classified the objects, substances and organisms. Classification was not based on similarities and differences or common attributes.
  - 49.89% students' classification skill was in developing stage wherein very few objects, substances and organisms were correctly classified based on similarities and differences.
  - 12.50% students' classification skill was in accomplished stage wherein students skilfully classified most of the objects, materials, substances and organism under correct classification based on common attributes.
  - 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.
- **With regard to Communication Skill**
  - 42.63% students' communication skill was in beginning stage wherein students could not draw line graph, bar diagram, pie chart, and tabular column correctly for the given data. They could not communicate through symbols, for e.g. they did not know the symbol for chemical elements and electric components. They drew diagrams correctly to some extent without labelling the parts.

- 35.71% students' communication skill was in developing stage wherein students correctly wrote the title of the graph, X axis and Y axis in the line graph and bar diagram but the line graph, bar diagram, and pie chart plotted by them were incorrect and incomplete. To some extent they could correctly communicate through symbols, tabular column and diagram.
- 12.72% students' communication skill was in accomplished stage wherein students almost plotted line graph, bar diagram and pie chart correctly. They drew tables correctly to some extent. Also they skilfully drew the diagram and labelled the parts correctly to some extent.
- 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.

- **With regard to Measurement Skill**
  - 54.16% students' measurement skill was in beginning stage wherein students incorrectly measured the length, breadth, height, and angle of the object and diagram. They could not find out the area of irregular object (leaf) accurately. They were unable to measure the temperature of water accurately. The volume of liquids measured with the help of pipette and burette was not precise i.e. much higher or lower than precise. Similarly, the length of curved line diagram was incorrectly measured with the help of thread, and they were unable to find out thickness of single page.
  - 13.69% students' measurement skill was in developing stage wherein students followed measurement procedure while measuring the length, breadth, height, angle, volume, area and temperature correctly to some extent but the measurement was not precise. Students correctly followed measurement procedure while measuring the area of irregular object (leaf), volume of water however the measurement was inaccurate and not precise. They could not measure the length of curved line.
  - 18.25% students' measurement skill was in accomplished stage wherein students correctly measured breadth and height of the table but length of the table was not measured accurately. The volume of water and $KMnO_4$ solution was measured in the pipette and burette with lower meniscus. They

correctly followed measurement procedure while measuring the total area of irregular object (leaf) and volume of irregular object but the measurement was inaccurate. The length of the pendulum measured correctly but could not calculate the time period of oscillation.

- 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 $KMnO_4$ 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.

- **With regard to Prediction Skill**
  - 54.91% students' prediction skill was in beginning stage wherein students' prediction was incorrect with regard to sinking and floating, miscibility and immiscibility, seed germination, time period of oscillation. For e.g. (i) Students' incorrectly predicted that ice cubes sink in water and water level increase during melting of ice cubes (ii) Students incorrectly predicted that castor oil and honey floats in water (iii) they predicted that kerosene and castor oil mix with water (iv) evaporation takes place faster in water than petrol.
  - 20.08% students' prediction skill was in developing stage wherein students' prediction was somewhat correct with regard to floating and sinking, miscibility and immiscibility of liquids, etc but they could not give any reasons for prediction. For e.g. (i) Students' correctly predicted that ice floats in water and correctly predicted that petrol evaporates faster than water but could not justify their prediction scientifically.
  - 18.75% students' prediction skill was in accomplished stage wherein students' prediction was correct and the reasons for prediction were also partially correct. For e.g. (i) based on the observations of simple pendulum experiment students correctly predicted the time period of oscillations and gave partially correct reasons. (ii) They correctly predicted that seed germinates faster in soil+ fertilizers and justified their prediction to some extent.

- 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.

- **With regard to Inference Skill**
  - 72.23% students' inference skill was in beginning stage wherein students could not derive inferences based on observations, instead they wrote observations of experiments, demonstration, videos and pictures. The students could not differentiate between observations and inferences.
  - 15.40% students' inference skill was in developing stage wherein students derive few inferences correctly to some extent. However they wrote more observations of experiments, demonstration, videos and pictures.
  - 8.70% students' inferences skill was in accomplished stage wherein students almost correctly derived inferences however few inferences could not be derived correctly and completely.
  - 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.

5.3 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.
- It was observed that the learning experiences such as hands on experience, field visit, multimedia presentation, role play, simulation and demonstration gradually improved students' science process skills in terms of

- Observing the similarities and differences between similar pictures and objects, noticing fine details of plant and animal specimens, observing the texture, smell, appearance of the chemicals.
- Classifying the things, substances and organisms into different category or groups based similarities and differences and presence and absence of certain features. For e.g. grouping the solids, liquids, gases; acids and bases; unicellular and multicellular; hydrophytes, xerophytes and mesophytes, etc.
- Displaying the results through line graph, pie chart, bar diagram, tables, symbols and diagrams, etc.
- Measuring length, breadth and height of the object, area of irregular leaf, volume of stone and temperature of water accurately.
- Writing measurements with appropriate units.
- Judging the range and capacity of measurement devices before use.
- Measuring the liquids accurately without lower and higher meniscus.

❑ Students correctly predicted the occurrences of events based on observations and experiences, also giving reasons for their prediction.

❑ Students correctly derived inferences based on observations of experiments and activities. They were also able to differentiate between inference and observation.

❑ The experimental skills were improved over a period of time.

5.4 Status of BSPS after Intervention Programme

❑ With regard to Observation Skill

- 3.79% students' observational skill was in beginning stage wherein students engaged in the process of observations but (i) could not observe any similarity and difference between similar pictures; (ii) could not use the magnifying lens and microscope for observing the fine details of the given specimens, and chemicals.
- 8.25% students' observation skill was in developing stage wherein students somewhat skilfully used their sensory organs and observed few similarities and differences between similar pictures; to some extent the students effectively used magnifying lens and microscope for observing the fine details of specimens; they observed the colour, smell, texture and appearance of few chemicals by employing their sense organs

- 18.08 % students' observation skill was accomplished stage wherein most of the similarities and difference between two similar pictures were observed. The Students observed most of the features such as colour, nature of body, number of body segment and body parts of the given specimens. The characteristics of chemicals in terms of smell, taste, texture, and appearance were also correctly observed.
- 69.86% students' observation skill was in proficient stage wherein students observed (i) similarities and differences between two similar pictures (ii) colour, smell, taste, texture and appearance of the chemicals observed correctly. The fine details of the given specimens were noticed by use of magnifying lens and microscope, for e.g. colour, appearance and smell of decayed bread observed correctly. They skilfully operated the microscope for observing the shape, types and arrangement of blood cells and blood components.

- **With regard to Classification Skill**
  - 1.78% student's classification skill was in developing stage wherein students somewhat able to classify the things, materials and substances into different categories or groups based on certain common characteristics or properties. For e.g. students correctly classified very few materials and substances into conductors and insulators; solids, liquids and gases; pure and impure substances; vertebrates and invertebrates, etc.
  - 15.67% students' classification skill was in accomplished stage wherein students classified most of the things, materials, substances, and organisms correctly based on similarities and differences, presence and absence of common features. For e.g students correctly classified most of them into conductors and insulators; magnetic and non magnetic; pure and impure substances; metals and non metals; soluble and insoluble substances; plants and animal based on common characteristics.
  - 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. For e.g. students skilfully classified the things, materials and substances into different groups such as solids, liquids, and gas; conductors and insulators; magnetic and non magnetic substances, etc.

- **With regard to Communication Skill**
  - 1.78% student's communication skill was in beginning stage wherein students could not draw pie chart, line graph and tabular column for the given data. They were unable to draw diagram and communicate through symbols.
  - 13.61% students' communication skill was in developing stage wherein students correctly plotted line graph, bar graph, pie chart and tabular column correctly to some extent but the plotted graph was incomplete (for e.g. X axis and Y axis written correctly students but plotted graph was correct to some extent pie chart was imperfect; drew inappropriate table and entered incomplete data). They could communicate through symbols, and diagram correctly to some extent.
  - 22.54% students' communication skill was in accomplished stage wherein students drew line graph, bar graph, pie chart and tabular column almost correctly with minor mistakes. For e.g. students drew graph for the given data with appropriate title, X axis and Y axis variables written correctly but the graph was imperfect. Similarly, pie chart was drawn correctly but partition was not made perfectly based on the data. The tabular column was drawn but data entered was incomplete.
  - 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.
- **With regard to Measurement Skill**
  - 3.57% students' measurement skill was in beginning stage wherein students could not measure the length, breadth, and height of the object; volume of water; total area of irregular object. They could not use the thermometer skilfully to measure temperature of water and did not know how to measure volume of irregular object. The Students did not use the measuring instruments skilfully while measuring the object or liquids, temperature.
  - 7.93% students' measurement skill was in developing stage wherein students measured length, breadth, height, area, temperature, and volume of a given object or liquids correctly to some extent but committed minor measurement error while measuring the size of the object or volume of the liquids. For e.g. students committed measurement error while measuring the $KMnO_4$ solution and water.

- 14.68% students' measurement skill was in accomplished stage wherein students skilfully used the measurement devices such as scale, tape, thermometer, protractor, pointer balance, measuring cylinder, pipette burette while measuring the length, breadth, height, temperature, mass (weight), time, thickness, area, and volume of object or liquids however committed minor error during measurement. For e.g. (i) students measured height and breadth of the table correctly but could not measure the length accurately (ii) students could not notice the lower meniscus while measuring the volume of liquids and $KMnO_4$ solution.
- 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. For e.g. (i) temperature of water was measured accurately (ii) volume of irregular object (stone) measured correctly (iii) volume of $KMnO_4$ solution and water was measured precisely with the help of pipette and burette.

❑ **With regard to Prediction Skill**

- 11.38% students' prediction skill was in beginning stage wherein students' predictions were incorrect with regard to floating and sinking, miscibility and immiscibility, seed germination, etc. For e.g. students could not predict correctly about floating and sinking of different liquids such as kerosene, castor oil, honey and diesel in water.
- 15.17% students' prediction skill was in developing stage wherein some of the predictions were correct but they could not give any reason or justification for the predictions. For e.g. students correctly predicted that ice cubes floats in water and level of water will be remain same while melting of ice cubes but they did not write any reason for their prediction.
- 22.09% students' prediction skill was in accomplished stage wherein most of the predictions were correct and the reasons stated for prediction were also partially correct. For e.g. students correctly predicted that ice floats in water and level of water remains same while melting of ice cubes and gave partially correct reasons for it.

- 57.33% students' prediction skill was in proficient stage wherein they correctly predicted regarding to floating and sinking of ice cubes and different object in water; miscibility and immiscibility of different liquids with water; on rain; evaporation of liquids; germination of seeds based on the evidences obtained through observations of experiments and past experiences. They also given correct reasons for their predictions.

- **With regard to Inference Skill**
  - 5.13% students' inference skill was in beginning stage wherein students could not derive inferences based on observation of picture, experiments, and videos, instead they wrote observations. For e.g. students observed root, stem, leaf, CO_2, O_2 and sunlight in the picture of plant photosynthesis but could not derive any inference(s) on photosynthesis. Similarly, experiments were conducted; videos were shown but students could not derive any inferences. The students were able to differentiate between inference and observations.
  - 8.14% students' inference skill was in developing stage wherein students derived inferences correctly based on observation of experiments pictures and videos to some extent but they could derive inference(s) completely.
  - 15.62% students' inference skill was in accomplished stage wherein students derived inference(s) based on observations of pictures, experiments, demonstration and videos almost correctly however few inference(s) students unable to deduce correctly.
  - 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 was 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 was 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 was rejected. From this it can be inferred that the experiential learning intervention programme was found to be 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 concluded 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. Hence, the null hypothesis Ho 7 was rejected. The difference was that the mean score was found to be higher in post test (33.33) as compared to the pre test (9.42). From this it can be inferred that the intervention programme found to be effective in' students achievement on 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.

Findings presented in this chapter give the clear picture of status of basic Science process skills before, during and after the intervention programme.

5.5 Discussion

Science is endless process; scientific knowledge and skills can be learned through various ways but there are some factors which influence the science learning such as motivation, attitudes, interest, learning environments and learning experiences, and learning materials. In addition to the above factors science learning greatly influenced by instructional strategies and evaluation. How school students learn science best? School students always desire to do experiments by their own. Learning becomes concrete and meaningful when there is interplay between learner and learning experiences. Science teaching should provide rich learning experiences to learner. If it fails to provide such opportunity for the students, then the learning becomes mechanical and monotonous. Present science teaching in schools largely dominated by textbook. Teacher continuously delivers content into students' minds; they often end up memorising the concepts. Teaching of science neglects the process of science, no practical experiences for the students, as a results students lacking behind even in simple process skills. Before implementation of intervention programme present study findings revealed that most of the students status of science process skills was in beginning stage wherein (i) they were unable to observe the differences and similarities between two similar objects or picture (ii) they could not observe the fine details of specimens with the help of microscope and hand lens (iii) they could not classify the object, substances and organisms based on similarities and differences (iv) most of the students could not measure the length, breadth, temperature, weight, volume and area accurately and (v) they were not able to communicate through line graph, bar diagram, pie chart, diagram, tables, symbols. They could not predict correctly the future events based on the experiences and observations and they could not derive inferences based on their observations and experience. Students of upper primary stage were in a position to observe, classify, communicate, measure, predict and infer. It was unfortunate that the students of upper primary not expert in basic science process skills such as observation, classification, communication, measurement, prediction and inference.

It can be inferred from the above findings that the science teaching rarely or did not expose the students in "learning by doing" method. Teachers were trained to read and understand the science concepts from textbook. Most of the time students copied answer from textbook and the same presented in the examination. Teaching was not constructive based, it was declarative and authoritative based. Malhotra (1998) and Umasree (1999) study findings indicates that teachers often use lecture method and students are rarely given opportunity to do science, students observe the teachers lecture rather than actively participating in the classroom. The examination system also focussed only cognitive aspects of science, process part of science not focussed. Teachers did not engage the students to make simple teaching aids by using waste materials. Teaching aids were not used or rarely used by teachers. Students were not engaged in the process aspects of science. Science equipments, apparatus and materials were not touched by students. Hands on learning experiences and activities were not emphasised by teachers, also they were not having enough competency to employ process skills. Variety of learning experiences such as field visit, role play, hands on experiences, model making, multimedia presentation, group activity were not provided by the teachers. Students did not do science experiments by own. Science equipments' and apparatus, preserved specimens, magnifying lens, chemicals and microscopes were unseen or rarely seen by students; as a result students were very poor in employing basic process skills.

Science laboratory is most important for science learning. Simple experiments, investigation in the laboratory, field visit, role play and teaching aids provides rich learning experiences to students. It is teachers' role to engage the students in appropriate learning environment for acquiring knowledge and skills. Children's process skills are limited and unsystematic in the beginning of upper primary stage; it is part of teachers' role to develop these skills so that when they get older, students approach the world in a systematic way. Unconsciously children at upper primary stage use basic process skills superficially at the time of exploration of the world. Science teachers' should identify the individual students' process skills status; accordingly opportunity should be provided to practice the skills regularly. Continuous assessment also required to know students process skills. Examination should focus more on process aspects of science. The assessment should not be confined to paper pencil test. Teachers need to use variety of assessment tools and techniques such as performance based test, situational test for assessing student's science process skills status.

Teachers also should have enough competencies in science process skills. It was stated by UNESCO (1992) in its document on "Teacher Competency" that process skills development is one of the important competencies for teachers. All policies and national level curriculum including NPE, 1986; NCF 2000 and 2005 made recommendation that teaching of science should develop process skills. Process skills cannot be acquired over a night; there should be experiments and activities, field visit, projects, demonstration, simulation, projects for the students to acquire necessary skills.

Why science teaching should emphasis more on process skills? What is the need of developing basic process skill at upper primary students? Process and products are inseparable from science. The products of science are outcome of process skills. By employing the process skills students constructs and reconstructs the concepts, modify the ideas. Harlen (1995) stated that if these process skills are not carried out in a rigorous and scientific manner then the emerging ideas will not necessarily fit the evidence. Basic process skills are the foundation for integrated process skills. The students who are proficient in basic process skills, they can exercise integrated process skills skilfully. Observation is starting point for science experimentation and investigation, it is crucial for making sense of the world at an early stage. Observation provides the children to explore the objects and their relationship. Observation promotes scientific thinking and it helps the children to understand the physical and biological world. During observation students employ all senses to collect qualitative and quantitative information such as noticing similarities and differences, fine details etc. Observation enables the students to use other basic process skills. Observation skill is not only for observing the events and fine details but also for sorting or classifying the things, objects, substances and organisms in a systematic manner based on similar characteristics. Classification skill develops divergent thinking and it promotes creativity. It also enables the students to give reason and to see the pattern of relationships that are the basis for concept development and generalisations. Communication is important in science. The observed findings and results should be communicated to others through verbal and non verbal methods such as graph, pie chart, tables and symbols. It is not only conveys the information but also helps for retrieve the informations whenever required. Students clearly can understand the results by looking at the symbols, posters, charts, and pie diagram and they able to compare the relationships pattern. Measurement in science is obvious. Measurement is act of using numbers to describe the objects and events. Students must understand the attributes that are measurable such as length, breadth, height, temperature, weight, angle and volume. They must know standardisation of measurements and appropriate measurement devices. Before measurement they must know the capacity of measuring devices, and accuracy in measurement. After measurement students must know how to write with proper measurements units. Measurement skill helps to sharpen their observations. Calculation is the part of measurement. It is therefore required by the students to know standard metric systems and to know process of conversion, for e.g. conversion of centimetre into millimetre vice versa; Celsius to Fahrenheit, etc. Students come to schools with rich experiences which can help to predict the future events and occurrences. Students very often guess without any base or observations. Predictions have strong basis or evidences, for e.g. before an experiment they can make prediction what will happen and during an experiment also they continue to predict about the events. But they do not have a well defined understanding of why things happen so. It is very necessary to have reason for their predictions. It is necessary that students should be engaged to carry out experiments and investigations to verify the prediction through which students come to know the cause and effect for the prediction and they acquire other process skills as well. Inference is an attempt based on observation of picture and experiments. It is common that students write observation instead of inferences, they observe the picture, experiments but cannot derive inferences based on available evidences. It is quiet difficult for the students to derive inferences based on experimentation and thorough observations. Teachers need to provide opportunity for the students to derive inferences by engaging them in an experiments and investigation regularly. Such activities develop inference skill and it stimulates higher order thinking skills, problem solving skills and metacognition process which have application in real life situation. Germann & Aram (1996) study findings indicate that development of science process skills enables students to construct and solve problems, critical thinking.

Process validity enables the students to solve problems, think critically, make decision, find answer, promote creativity and it increases the permanence of learning. It was stated by NCF (2005) that process validity is an important criterion since it helps in 'learning to learn' science. But present study finding reveal that most of the time science teachers read the textbook and explain the concepts. Students listen to the teachers lecture. There were no direct hands on learning experiences for the students to explore process skills. When the students exposed in experiential learning intervention programme, gradually they acquired the skill of observation, classification, communication, measurement, prediction and inference. Intervention programme provided opportunity for the students to employ the sensory organs and observed the colour, smell, texture, appearance of chemicals. They classified the things, substances and organisms based on similarities and differences. Students communicated the results observations through line graph, bar diagram, pie chart, tables, symbols and diagram. They skilfully used the measurement devices such as scale, measurement tape, thermometer, pipette burette, measuring jar for measuring the length, breadth, weight, volume, area of objects. Students predicted correctly with regard to future events and occurrences and they could derive inferences based on the observations and experiences.

Before implementation of intervention programme, present study findings reveal that most of the students science process skills status was in beginning stage wherein after intervention programme most of the students science process skills was in proficient stage. Students' achievement on science process skills also increased significantly after intervention programme. It indicates that the intervention programme facilitated the students to acquire basic process skills, also they understands the concepts of science process skills. This is due to the following learning experiences such as hands on experience, multimedia presentation, field visit, role play, demonstration, and simulation. The Kolb's experiential learning facilitated the students to observe, experiments, reflects. The same findings were reported by Arnold and Warner (2006) that experiential learning offers (i) quality experience (ii) the active engagement and reflective observation useful for comprehensive understanding of knowledge and skills. Gorden (2006) study findings also reported that hands on science experience improved science process skills. Findings further reported that the students observe and classify the objects in home. Research study findings also reveal that process skills cannot learn by lecture method. From the above observations it can be said that traditional chalk and talk method cannot enhance process skills. Learner centred, constructive based approach is needed. Kasinath (2000) in his study used inquiry approach for developing process skills, the study findings reveal that inquiry model was more effective than the conventional method for fostering process skills. Ramkumar (2003) study findings reports that environmental approach developed process skills. Bhaskar (2010) employed constructivist approach; the findings reveal that the constructive approach enhanced process skills among students. Hence, it is recommended that science teaching of science should discard lecture method. Instead, experiential learning method should be adopted to develop knowledge and skills. Process skills domain should be included in the teacher education curriculum so that pre-service teacher can nurture these skills in young students. Amin (2011) used activity based science teaching among pre-service teachers. Findings reveal that the demonstration and multimedia are thee learning experiences improved science process skills.

Jean Piaget stated that children learn from an interaction between their experiences and their ideas. From a constructivist view of science, learners' personal involvement and experiences are ultimate principle; such learning is more concrete instead of hearing or reading. There are some constructivist approaches such as cooperative learning, activity based learning, inquiry learning, ICT aided approach etc which were adopted by various researchers for developing science process skills and the findings reveal that the methods found to be effective (Ramkumar, 2003; Amin, 2011; Kasinath, 2000). Similarly, experiential learning is one of the constructive based learning approaches wherein students can acquire basic process skills and concepts by their own. In a nut shell, experiential mode of learning needs to be adopted to learn science concepts and skills.

CHAPTER VI
SUMMARYAND 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 experimenting, 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 VIIIth 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,

Phase I	**Study the status of BSPS before implementation of intervention programme.**
Phase II	**Development and implementation of intervention programme**
Phase III	**Assess what extent students acquired BSPS after implementation of intervention programme**

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 $KMnO_4$ 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.

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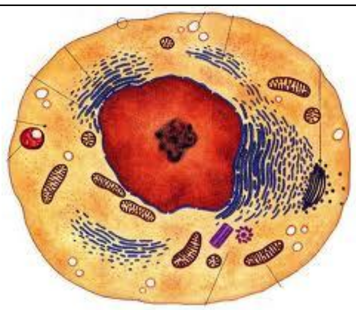
APPENDIX_1.1

Questionnaire for Observation Skill

Name of the Student : **Medium : English**

Name of the School : **Standard: VIII**

1. Carefully observe the picture of a plant cell and animal cell. Write any three similarities and three differences between them.



No	Similarities	Differences
1.		
2.		
3.		

2. A glass of water with pencil and a coin kept for observation. Carefully examine and write four observations below.

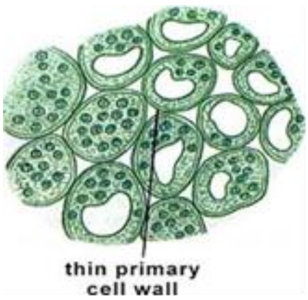
No	Observations
1.	
2.	
3.	
4.	

3. See the flame of lighted candle. Observe carefully and write any four observations in the tabular column.

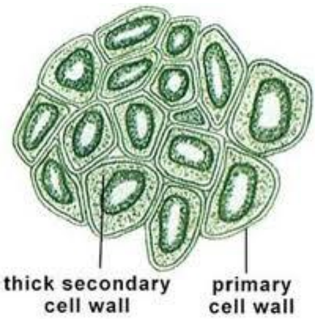
No	Observations
1.	
2.	
3.	
4.	

4. Observe the pictures of parenchyma and sclerenchyma cells. Write three differences and three similarities between the two different types of cells.

Parenchyma



Sclerenchyma



No	Similarities	Differences
1.		
2.		
3.		

5. Carefully observe the real specimens of ginger and potato. Spot out four differences between them.

[Zinger and potato specimens kept for observation]

Differences		
No	Ginger	Potato
1.		
2.		
3.		
4.		

6. Observe the decayed bread with the help of magnifying lens and write four observations in the table below.

No	Observations
1.	
2.	
3.	
4.	

7. The thermometer is kept in the beaker containing hot water. Observe the level of mercury in the thermometer and write the exact temperature of hot water.

The level of mercury in the thermometer is------------------------.

8. The preserved specimen of centipede is kept for observation. Examine carefully and write minimum four observations in the tabular column.

No	Observations of centipede
1.	
2.	
3.	
4.	

9. There are some chemicals substances kept for observation, they are marked as A, B, C, D, E, F, G and H. Feel the taste (only testable), appearance, smell, texture, and special features if any and write down in the table.

Chemicals	Taste	Appearance	Texture	Smell	Special features if any
A.					
B.					
C.					
D.					
E.					
F.					
G.					
H.					

10. Silently hear the audio about the Saturn planet in the computer and answer the following questions.

[Audio on Saturn planet was played to the students and asked them to listen completely. After completion of audio, the following questions were written on the board to respond].

a) Saturn is planet number -------------in the solar system

b) Saturn is also contains the gas like the planet--

c) The atmosphere of Saturn is similar to the planet------------and it is made up of --------------gas and --------------- gas.

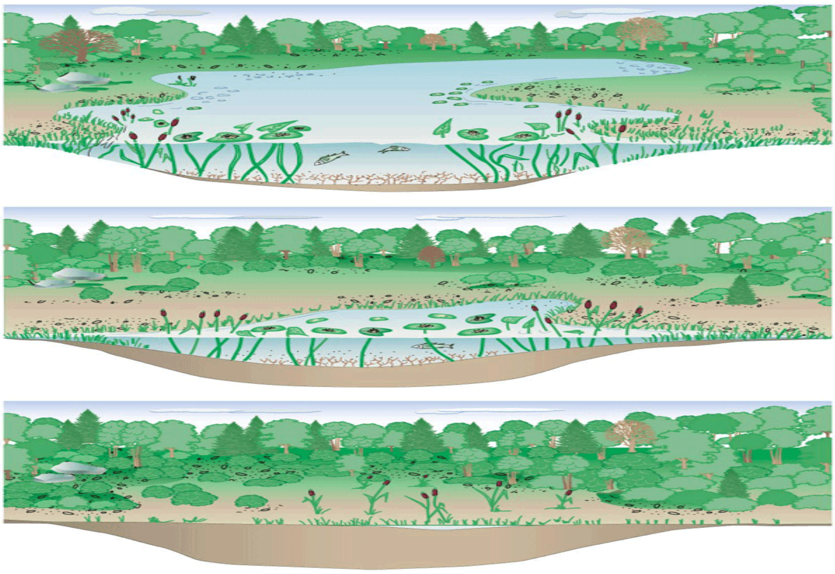
d) The average temperature of Saturn is

e) Saturn is times bigger than the planet

11. Observe the Human blood tissues slide in the compound microscope and write your observations about different types of blood cells.

[Preserved Human blood tissue was kept it on microscope for observation; students were engaged to observe the slide]

12. The aquatic succession picture shown below. Observe carefully and write four observations of figure (A), (B) and (C).



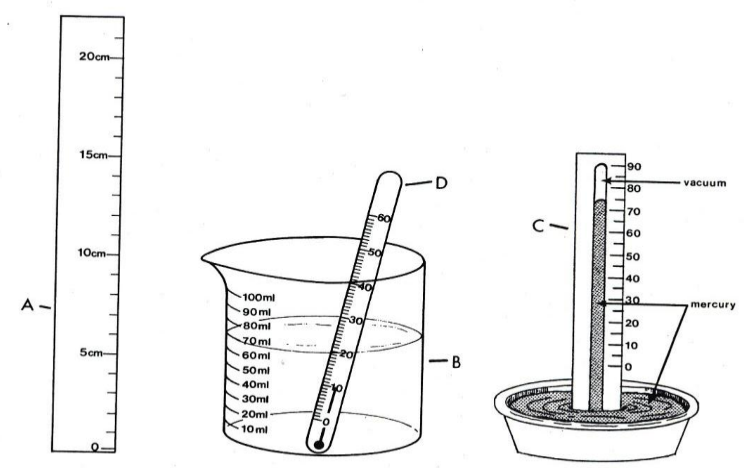
(a)

	Observation on picture (A)	Observation on picture (B)	Observation of picture (C)
1.			
2.			
3.			
4.			

13. Examine the sand kept for observation and spot out any four observations.

No	Observations
1.	
2.	
3.	
4.	

14. Observe the diagrams below, and answer the following questions.



a). What is the exact temperature of the liquid in the beaker?

The exact temperature of water in the beaker is……..

b). Quantify the amount of air present in the trough “C”?

The amount of air present in the trough is……

c) The exact height of the beaker is…….

15. Observe the preserved specimen of spider in the bottle. Write any four observations about the same.

[Preserved specimen of spider kept it for observations]

	Observations
1.	
2.	
3.	
4.	

16. Observe the plant specimen kept it for observation. Write your observation in the tabular column below.

[A small tender plant was kept it for observation, all the students observed the plants].

Observations		
Leaves	Roots	Stem

APPENDIX_1.2

Questionnaire for Classification Skill

Name of the Sstudent : **Standard: VIII**

Name of the School : **Medium: English**

1. Classify the following such as Graphite, Scale Steel, Earth, Glass, Plastic bangles, Iron nails, Copper wire, Charcoal, Silicon, Aluminum foil, Mica, Leather object, Thermocole, Wood, Marbles, Plastic and Ebonite into conductors and Insulators.

Conductors	Insulators

2. Various objects such as Iron ball, Nickel, Coin, Scale steel, Paper clip, Silver object, Plastics, Key chain iron, Aluminum object, Cobalt, Iron fillings, Safety pin, Fiber sheet and Scissors are kept for classification. Carefully observe and classify them into magnetic and non-magnetic substances.

Magnetic substances	Nonmagnetic substances

3. The pictures of different organisms are shown below. Based on the similarities and differences the organisms can be classified into different groups. Identify and classify them into different groups as you feel correct and give reasons for your classification in the table given below.

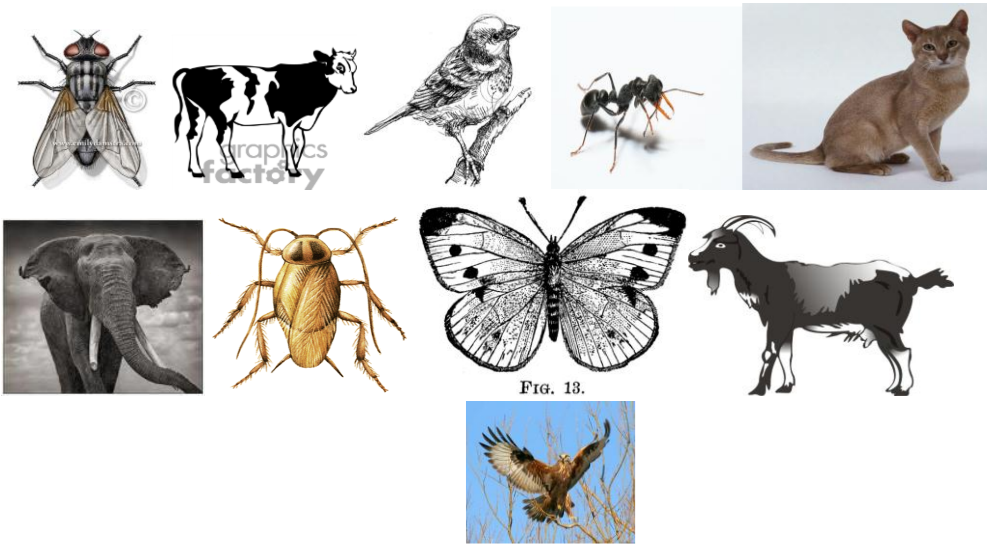


FIG. 13.

	Classified into	**Name of the organisms**	**Reasons**
1.			
2.			
3.			
4.			
5.			
6			

4. Classify the following (Fuming agarbatti, Spectacles, Perfumes, Mercury, Smoke, LPG, Clouds, Stream, Wax, Cork, Empty test tubes, Inflated balloon, and Methane) into solids, liquids and gases.

Solids	Liquids	Gas

5. Observe the various substances and solutions such as water, salt solution, sugar solutions, potassium permanganate solution, and water with sand. Classify them into pure substances and impure substances, opaque and transparent solution. Put **TICK** mark whichever is applicable.

	Type of Substances	Water	Sugar solution	Salt solution	$KMnO_4$	Water +Sand
1.	Pure substances					
2.	Impure substances					
3.	Opaque					
4.	Transparent solution					

6. Various elements such as silver, gold, iron, helium, copper, Cl_2, silicon, sodium, aluminum, talcum powder, baking soda, sulphur, carbon and washing soda are kept. Carefully notice and classify them into metals and non-metals.

Metals	Non metals

7. The following plants such as Eichhornia, Euphorbia, and Sunflower plant, Heterophylla, Wolffia, Hibiscus, Nelumbium, Opuntia, Mango and Cerotophylum are having similar characteristics in their habitat. Identify and classify into hydrophytes, mesophytes and xerophytes.

Hydrophytes	Mesophytes	Xeophytes

8. The following animals Squirrels, Crow, Chameleon, Proteus, Spider monkey, Parrot and Salamander are having similar features in respect to their place of living. Classify them into arboreal animals, aerial animals and cave animals.

Arboreal animals	Aerial animals	Cave dwelling animals

9. Various objects such as wood, iron, pure water, cellophane sheet, glass piece, plastics, clothes, thermocole, paper, cardboard sheet are kept on the table. Observe carefully and classify them into transparent, translucent and opaque materials. Put **TICK** marks as u feel correct.

	Substances	Wood	paper	Water	Cello tap	Glass piece	plastic	clothe	cardboard	Thermocoal	Iron
1.	Transparent										
2.	Translucent										
3.	opaque										

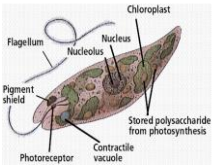
10. The pictures of animals are shown below. Observe them carefully and classify them into herbivores, carnivores and Omnivores

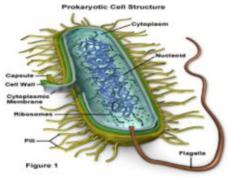
Herbivores	Carnivores	Omnivores

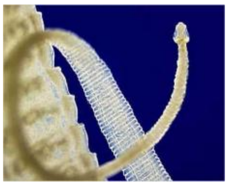
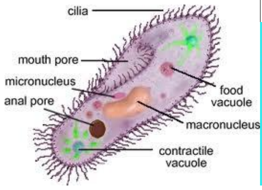
11. Various substances such as sand, washing soda, Quick lime, common salt, Caustic soda, baking soda, bleaching powder, Caustic potash, Iron (III) hydroxide, Slaked lime and wood powder and iron powder are kept for classification. Observe and classify them into soluble and insoluble substances in water.

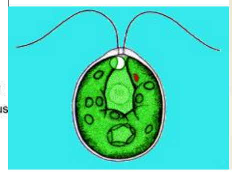
Name of substances which Soluble in water	Name of substances which insoluble in water	Name of substances which Slightly soluble in water

12. The pictures of various organisms are given below. Observe and classify them into unicellular and multicellular organisms. Put **TICK** marks as u feel correct.

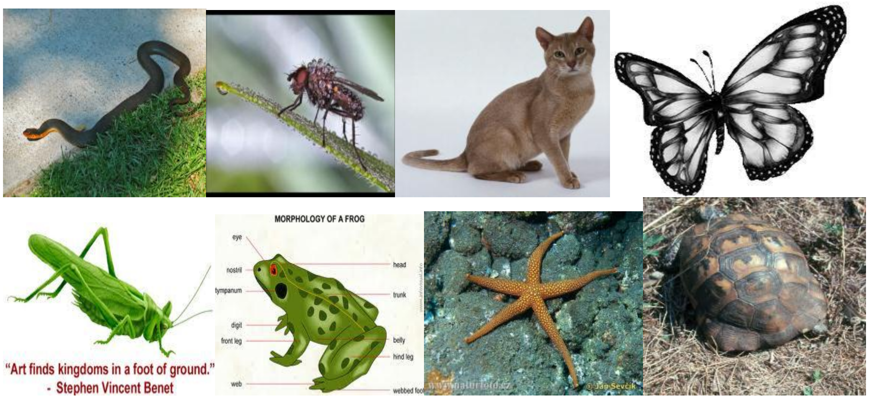



Name of the Organisms	Unicellular	Multicellular
Snail		
Rabbit		
Tape worm		
Euglena		
Bacteria		
Paramecium		
Liver fluke		
Chlamydomonas		

13. Some of the organisms' names are given below, carefully observe and classify into amphibians and reptiles. Put **TICK** marks as u feel correct.

Name of the animals	Amphibians	Reptiles
Snake		
Insect		
Star fish		
Cat		
Butterfly		
Tortoise		
Grass hopper		
Frog		

14. Observe the pictures of animals shown below. Classify them into vertebrates and invertebrates. Put **TICK** marks as u feel correct.

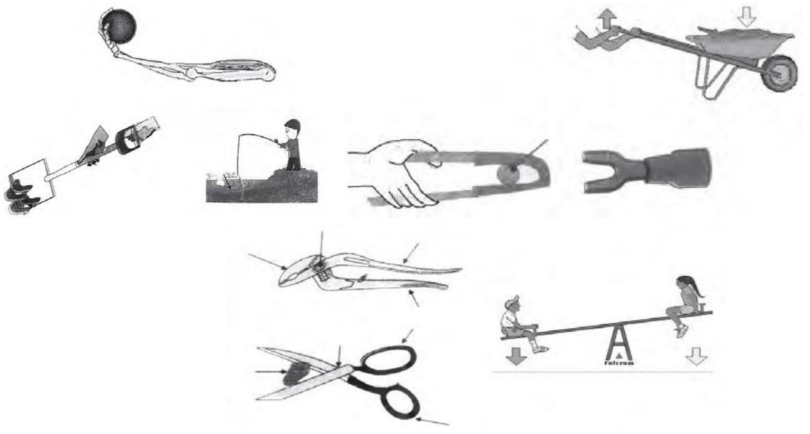


Name of the organisms	Vertebrates	Invertebrates
Snake	Snake	
Insect		
Star fish		
Cat		
Butterfly		
Tortoise		
Grass hopper		
Frog		

15. Various kinds of substances such as tamarind, soap solution vinegar, grape juice, NaOH, lemon juice, Calcium oxide, KOH solution, alcohol, Calcium hydroxide, Magnesium hydroxide, and caustic soda are kept in separate beaker. Observe the demonstrations of acid base test by using litmus paper. Classify whether the substances are acid or base**.** Put **TICK** mark whichever is correct

Substances	**Acids**	**Bases**
Tamarind		
Soap solution		
Vinegar		
Grape juice		
NaOH		
Lemon juice		
Calcium oxide		
KOH Solution		
Alcohol		
Calcium hydroxide		
Megnesium hydroxide		
Caustic soda		

16. The pictures of levers such as see saw, nut cracker, bottle opener, fishing rod, wheel barrow, scissors, spade and arm. Classify them into first order, second order and third order lever. Put **TICK** mark whichever is applicable.



Levers	First order levers	Second order levers	Third order levers
Nut cracker			
Bottle opener			
Crowbar, tongs			
See saw			
wheel barrow			
Spade			
Scissors			
Human fore arm			
Fishing rod			

17. Classify the following substances such as dal, wheat, mung dal, maize, green gram, rye, Bengal gram, rice, ragi and horse gram into pulses and Cereals.

Pulses	**Cereals**

18. The fruits name such as Mango, Coconut, Drum stick, Dates, Dates, Grapes, Brinjal, Cotton fruits and cashew nut are given. Classify them into dry fruits and fleshy fruits.

Dry fruits	**Fleshy fruits**

APPENDIX_1.3

Questions for Communication Skill

Name of the Student: **Standard: VIII**

Name of the School: **Medium: English**

1. The following table shows the detail about a car which is moving with a velocity in respect to the time; plot the line graph for velocity of car versus time.

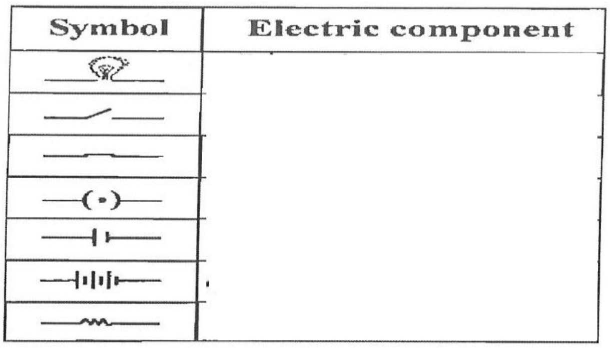
[Graph sheet was provided to the students separately for plotting the graph]

Time in (Minutes)	10	20	30	40	50	60	70	80	90
Velocity (Km)	5	10	15	20	25	30	40	45	50

2. Look at the tabular column below, it gives the details about calorific requirements for adults (both male and female) according to their age. Draw the bar diagram for the same.

S. No	Age (in years)	Requirement of calories per day. (for Men)	Requirement of calories per day. (for Women)
1	20 - 30	3200	2950
2	30 - 40	3100	2750
3	40 – 50	3000	2650
4	50 - 60	2750	2550
5	60 -70	2500	2300
6	70 - 80	2200	1900

3. The following table contains some symbols which are used to describe different component in electric circuit diagram. Write the name or functions of the electric component opposite to the respective symbols.



4. Carefully look at the diagrams given below. Draw the correct arrow mark so that the flow of energy from sun to different organisms will be completed.

HEAT

PLANT PRODUCERS | **HERBIVORES** | **CARNIVORES** | **OMNIVORES**

DECOMPOSERS

(Fungi and bacteria)

5. The names of different animals are given below. Draw the correct arrow mark to show their interrelationship, so that the food web will be completed. Write description about how they are interrelated in the food web as you drawn the arrow mark.

Hawk

Rabbit **Snake**

Rat

Frog

Plants **Grass hopper**

6. The following table contains numerical data about when a body travels with uniform speed with respect to the time. Plot the line graph for the same.

[Graph sheet was provided separately to the students for drawing the line graph]

Time (in sec)	0	1	2	3	4	5
Distance (metre)	0	5	10	15	20	25

7. The following table contains numerical data about when a body travels with non-uniform speed with respect to the time. Plot the line graph for the same.

[Graph sheet was provided separately to the students for drawing the line graph]

Time (in sec)	0	1	2	3	4	5
Distance (metre)	0	5	12	20	25	35

8. The following elements such as Common salt, Gold, Silver, Tin, Lead, Carbon and Oxygen are represented by some symbols which are given below. Write correct name corresponding to the symbols**.**

9. The percentage of different gases in the atmosphere is given below. Draw a neat pie diagram for the same and differentiate the percentage of different gases.

Percentage of different gases	**Pie diagram**
Nitrogen 78% **Oxygen 21%** **CO2 0.03%** **Noble gas 0.9%**	

10. Carefully look at the diagram of Human heart in the chart. Draw a neat diagram and label them neatly.

[Human heart diagram chart was displayed, and students were asked to draw the same].

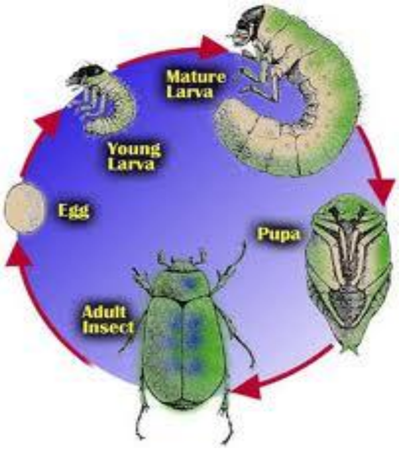
11. The following are the scientific symbols of certain elements such as H, Li, C, K, N, Na, Ba, Cu, Hg and Fe. Write the name of above elements in the tabular column.

S.No	Symbols	Name of the elements
1	H	
2	Li	
3	C	
4	K	
5	N	
6	Na	
7	Ba	
8	Cu	
9	Hg	
10	Fe	

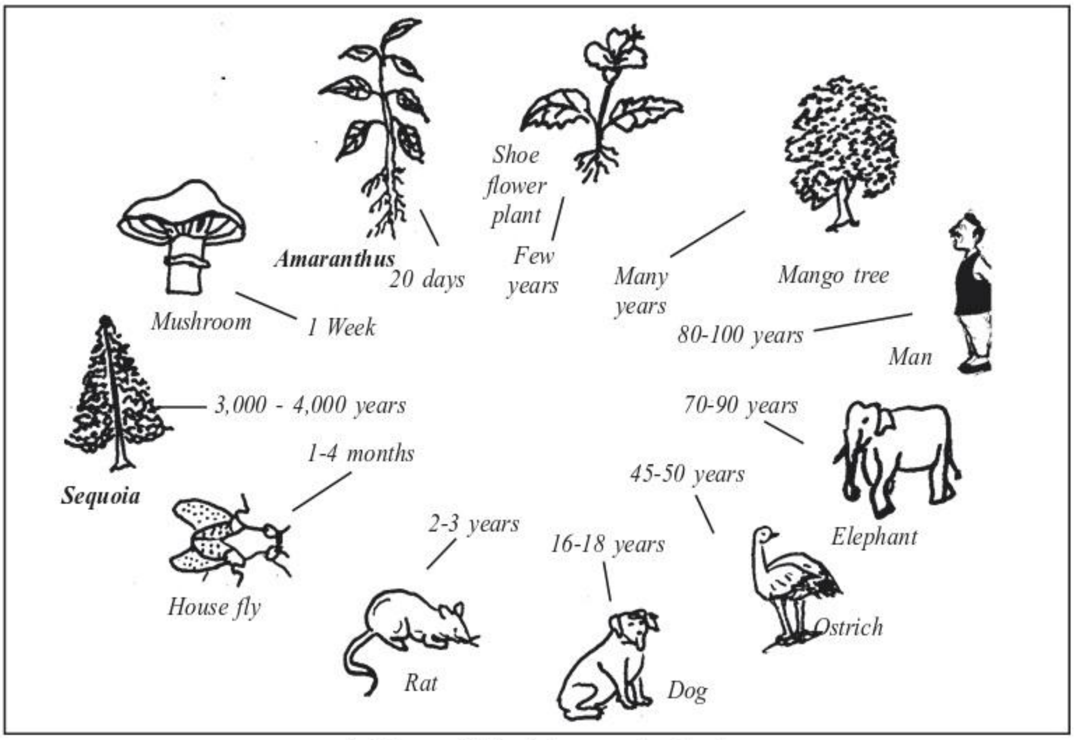
12. Look at the model of human brain. Draw a neat diagram of the same and label them.

[Human brain model was displayed, students drew the same]

13. Observe the diagram of life cycle of insect, describe in detail about each stage.



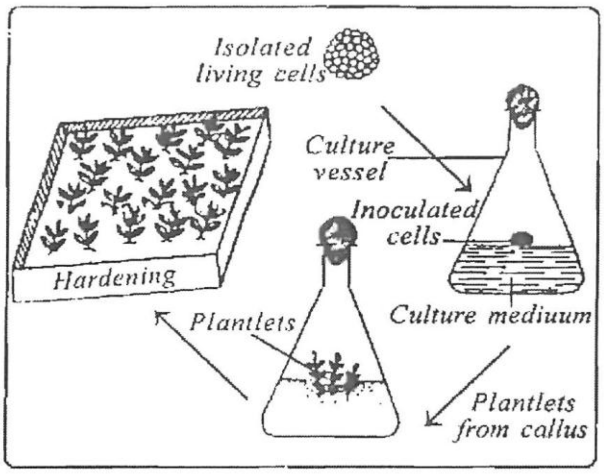
14. Look at the diagrams below, different organisms and their life span are given. Make a tabular column and write name of the animals / plants, number of days / weeks / months or years of living and find out the organisms which has shortest and longest life span.



8.6 Span of life of plants and animals

15. Sodium carbonate reacts with hydrochloric acid gives sodium chloride and carbon dioxide and water. Write chemical equation for the above reaction.

16. Look at the picture below. Different steps are given for tissue culture; write a simple flow chart to show the steps in tissue culture techniques.



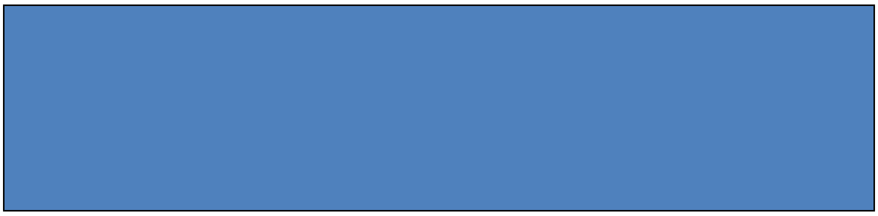
APPENDIX_1.4

Questionnaire for measurement Skill

Name of the Student : **Standard: VIII**

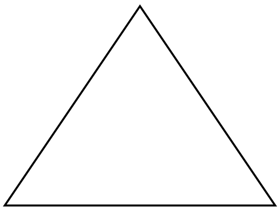
Name of the School : **Medium: English**

1. Measure the following diagram using appropriate device and write the length and breadth accurately.



Length (cm)	Width (cm)	Device(s) used

2. Measure the vertical height and its base of the following triangle diagram using appropriate measuring device and write vertical height and base of the triangle accurate.



Vertical height (cm)	Base (cm)	Device(s) used

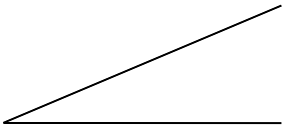
3. Water is kept in a 500 ml beaker. Take 75 ml of water exactly using the measuring cylinder and write remaining amount of water in the beaker.

Amount of water Taken in the beaker is	Remaining amount of water in the beaker (ml)
Exactly 75 ml / Less than 75 ml / More than 75ml	

4. Measure the length, breadth and height of the cuboid using standard measuring device and write accurate measurement below.

Length (cm)	Breadth (cm)	Height (cm)	measuring device(s) used

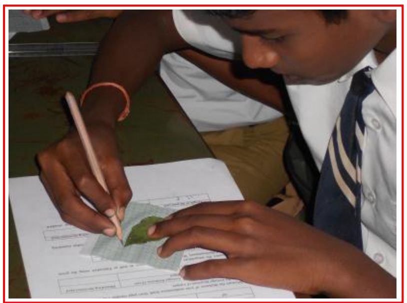
5. Measure the angle between two lines of the following diagrams by using proper measuring device and write accurate measurement below.



Angle between two lines	Device(s)used	Angle between two lines	Device(s)used

6. Measure the total area of the given irregular leaf using graph sheet and write accurate measurement.

A leaf was given to students to draw the outline and measures the total area of leaf



The total area of the leaf is (cm)

7. Measure the weight of the given bag using pointer balance and write weight of the bag.

[Pointer balance was given to students for measuring the weight of bag]

Weight of the given bag (Kg)	Name of the balance used to measure

8. The hot water and cold water is kept in the beaker separately. Measure the exact temperature of the given hot water and cold water using the thermometer and write the measurement below.

[Hot water and cold water given separately for measuring the temperature]

Temperature of hot water	Temperature of cold water

9. Measure the length, breadth and width of the table with the help of measuring tape and write measurement accurately in the table below.

[Table was placed in the classroom for measuring the length breadth and width]

Length of the table	Breadth of the table	Height of the table	Name of the measuring device used to measure

10. The water in a measuring cylinder, thread and stone are kept. Determine the volume of irregular object (stone) using displacement method of water.

11. Measure the length of the given pendulum, make it to oscillate and record the time taken for ten oscillations and calculate the time taken for one oscillation.

[Simple pendulum experiment was kept on the table to measure the length and time taken for ten oscillations, students asked to measure the same].

Length of the pendulum	Time taken for 10 oscillations	Time taken for one oscillations

12. Appropriate measuring device and a piece of cloth are kept on the table. Measure the length and breadth of the cloth accurately.

Length of the cloth	Breadth of the cloth	Device(s) Used to measure

13. Burette with potassium permanganate solution is fixed in a stand; take exactly 15 ml of potassium permanganate solution in a beaker.

Volume of potassium permanganate solution taken in a beaker is	Remaining amount of potassium permanganate solution in the burette

14. Look at the beaker containing water, pipette out exact 20 ml of water with the help of pipette tube.

[A beaker with water given to students for pipette out 20 ml of water exactly]

The quantity of water i pipette out		
Exact 20 ml	More than 20 ml	Less than 20 ml

15. Measure the thickness of your mathematics book from page number one to last page number. Find out the average thickness of a paper.

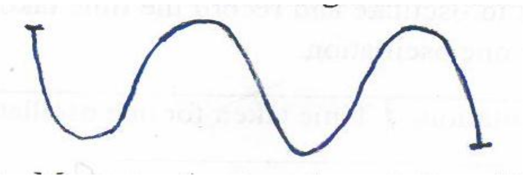
Thickness of mathematics book (in cm)	Average thickness of one paper	Measuring device(s) used

16. Measure the temperature of classroom in Celsius as well as Fahrenheit scale using the given instrument (thermometer). Write measurement below.

[A thermometer having Celsius and Fahrenheit readings given to students for measurement]

Temperature of lab in Celsius	Temperature of lab in Fahrenheit

17. Measure the length of this curved diagram (thread) given below by using the suitable measurement method and write total length of the curved diagram.



Length (cm)	Measuring device(s) used

18. Measure the length and breadth of the given post card accurately using standard measuring scale.

[A post card was given to the students for measurement]

Length of the post card	Breadth of the post card

APPENDIX_1.5

Questionnaire for Prediction Skill

Name of the Student: **Standard: VIII**

Name of the School: **Medium: English**

1. The ice cubes and water in a beaker are kept for experiment. Predict your answer for the following questions.

a) Write your prediction; if ice cubes dropped in to the beaker containing water, will it float or sink? Write reasons for your answer.

Prediction	Reason(s) for prediction
I predict Ice cubes will …….	Because…density of ice cubes is lesser than water and

b) Predict, whether water level will increase or decrease or remain same during melting of ice cubes. Write reasons for your answer.

Prediction	Reason(s) for prediction
I predict water level will be	Because…

2. Observe the demonstration of a simple pendulum experiment with 40 cm length and count 20 oscillations. Note down the time taken for 20 oscillations, based on your observations predict the following questions.

[Simple pendulum experiment was demonstrated to the students before making prediction]

a) Look at the simple pendulum experimental setup. Write your prediction, If length of the pendulum is **40 cm (metal bob), what will be the time period for 28 oscillations. Write down reasons for** your prediction.

Prediction	Reason(s) for prediction
I Predict the time period for 28 oscillations is -----------Seconds	Because……

b) What will be the time period for 30 oscillations, if length of the pendulum is 50 cm (metal bob). Write down the reason for your prediction.

Prediction	Reason(s) for prediction
I predict the time period for 30 oscillations is -----------seconds	Because…….

c) If length of the pendulum is 60 cm, what will be the time period for 10 oscillations? Give reasons for your prediction.

Prediction	Reason(s) for prediction
I predict the time period for 10 oscillations is --------------seconds	Because…….

3. Different liquids such as kerosene, castor oil, honey, diesel, water and beaker are kept. When you pour each liquid into the beaker, predict which liquid floats first, second, third, fourth and fifth from top to bottom of the beaker. Write reasons for your prediction.

	Liquid floatation from top to bottom	Reason(s) for prediction
1.		Because…
2.		
3.		
4.		
5.		

4. Different solutions such as salt solution, sugar solution and pure water are kept separately in different beaker. Write your prediction for the following questions.

a) When you place the egg in pure water, whether egg will float or sink? Give reasons for your prediction.

Prediction	Reason(s) for prediction
I predict, in pure water egg will…	Because….

b) If you keep egg in salt solution, whether the egg will float or sink? Give reasons for your prediction.

Prediction	Reason(s) for prediction
I predict, in salt water egg will…	Because…

c) Suppose you drop the egg in vinegar (acetic acid), whether the egg will float or sink? Give reasons for your prediction.

Prediction	Reason(s) for Prediction
I predict, in sugar solution egg will	Because…

5. Two joined plane mirrors are kept for observation. Look at the two joined mirrors carefully and predict the angle between the two mirrors at different trials.

S. No	Predicted angles between two mirrors
1^{st} Trail	… Degree
2^{nd} Trail	… Degree
3^{rd} Trail	… Degree
4^{th} Trail	…Degree

6. There are some vegetables and materials such as tomato, brinjal, egg, erasers, pencils paraffin fax, kerosene, and water kept on the table. If you put each vegetable / material into different liquids (water and kerosene), predict will it float or sink? Write your prediction **“Sink”** or **“Float”** of each object in the given liquid.

S. No	Vegetable / Substances	Sink/float in water	Sink/float in kerosene	Reasons
1.	Tomato			Because
2.	Brinjal			Because…
3.	Erasers			Because…
4.	Pencil			Because…
5.	Paraffin wax			Because…

7. The hot water and cold water are kept separately in the beaker. Predict the temperature of water by touching. Write your prediction in the tabular column. Later mix both (hot and cold water) and predict the temperature of mixed water by touching and write in the tabular column.

Type of water	I predict the temp is
Hot water (half Litre)	^oC
Cold water (half Litre)	^oC

8. 50gms of different substances such as crystal sugar, crystal salt, jaggery and water are kept in a separate beaker. If you put them into water separately at a time, predict which substance will dissolve faster than other.

Prediction	Reasons
I predict…………will dissolve faster than the other substance.	Because...

9. Liquids having different densities such as coconut oil, kerosene, petrol, honey and water are kept separately in the beaker. Predict which the liquid mixes with water. Write reasons for your prediction. (Put TICK mark for mix and CROSS mark for do not mix)

I Predict the following Liquid(s) will mix with water	Reason(s) for prediction
Kerosene + Water	
Coconut oil + Water	
Petrol + Water	
Castor oil + Water	
Honey + Water	

10. Carefully observe the thistle funnel experiment (osmosis). The thistle funnel contain sugar solution and beaker containing water, both are separated by semi permeable membrane. Write your prediction whichever you feel correct.

Prediction	Reasons
a) I predict that the level of water in the beaker will increase due to the entry of sugar solution from the thistle funnel.	Because…

b) I predict that the sugar solution will increase in the thistle funnel due to the entry of water from beaker.	Because…
c) I predict that the level of sugar solution in thistle funnel and level of water in the beaker will be remaining same.	Because…

11. There are two pots marked as **A** and **B.** The pot **"A"** contains mixture of soil + fertilizer and the pot **"B"** contains mixture of soil + manure. Predict if you sow same quantity of bean seed into both the pots, which potted seed will germinate faster. Put **TICK** mark for your prediction.

Prediction	Reasons
a) I predict that seed will germinate faster in pot **"B"** **b)** I predict that seed will germinate faster in pot **"B"**	Because….

12. If **e**qual size of ice cubes are kept in different places such as dark room, salt solution, cold water and sugar solution. Predict in which of the following place the ice cubes melts faster than the other place. (Mark any one which you predict)

Prediction	Reasons
I predict ice cubes melts faster in a) Cold water b) Dark place c) Salt solution d) Sugar solution	

13. If 500 ml of hot water at 50^0 C temperatures kept in different vessels such as aluminium, brass, mud pot, steel and plastic vessel at least an hour in same place. Predict, in which vessel the temperature of hot water will lower down faster. Predict any one and put tick mark.

Prediction	Reasons
I predict that the temperature of hot water lower down faster in a) Aluminium vessel b) Brass vessel c) Mud pot vessel d) Steel vessel e) Plastic vessel	Because…

14. There are two larger area glass bowls. One bowl contains 10 ml of water and other bowl contains 10 ml of petrol. Predict if you keep both the bowls in the sunny place, which liquid evaporates faster than the other. Put **TICK** mark which you predict.

Prediction	Reason for prediction
a) I predict water evaporates faster than petrol b) I predict petrol evaporates faster than water	Because…

15. You might have observed the rain and weather in the past week. Now you observe the clouds outside the classroom and predict whether this evening going to be rain or not.

Prediction	Reason(s)
I predict this evening going to be rain (a) Yes (b) No	Because…

16) Observe the picture of worm with plant and write your prediction on the same.

APPENDIX_1.6

Questionnaire for Inference Skill

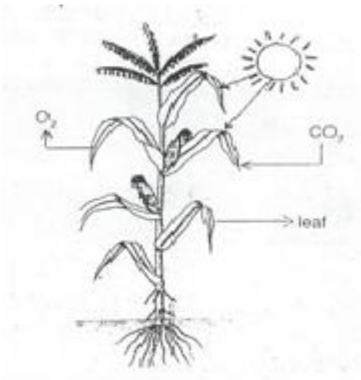
Name of the Student : **Standard: VIII**

Name of the School : **Medium: English**

1. Look at the experimental setup. Thermometer with ice cubes is placed in the glass funnel and it is kept in an empty beaker. Notice the water dripping into the beaker through glass funnel. Carefully observe the temperature in the thermometer and other changes in the ice cubes. Write inferences based on your observations.

Inference(s)

2. Carefully observe the picture of a plant shown below, what you infer from this plant picture.



Inference(s)

3. Wood powder, dust, iron powder, sand and common salt are kept separately. Observe well, while mixing in a beaker containing water. Examine carefully and write inferences based on your observation.

Inference(s)

4. The following substances such as lemon juice, tamarind, grapes, Vinegar, NaOH, potassium hydroxide and calcium hydroxide are kept separately. Observe the blue litmus paper and red litmus paper when dipping into each substance. Notice the colour change of litmus paper and write inferences based on your observations.

[Acid and base test was done in each substance with the help of blue litmus and red litmus paper. Students observed the colour change of litmus paper, and the same entered in the table below. Based on the observations, students derived inferences].

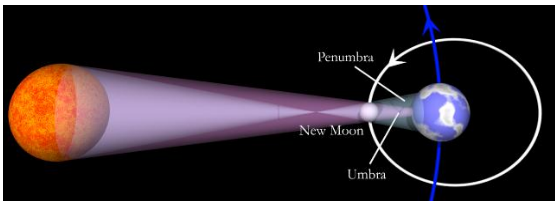
	Substances	Effect on Red litmus	Effect on Blue litmus
1.	Lemon juice		
2.	Vinegar		
3.	Tamarind		
4.	Grapes		
5.	NaOH		
6.	KOH		
7.	$CaCO_3$		

Inference(s)

5. Observe the experiment; five drawing pins are fixed on the metal rod with the help of wax. Heat is supplied at the edge of metal rod. Carefully observe the falling of pins and write inferences based on your observation.

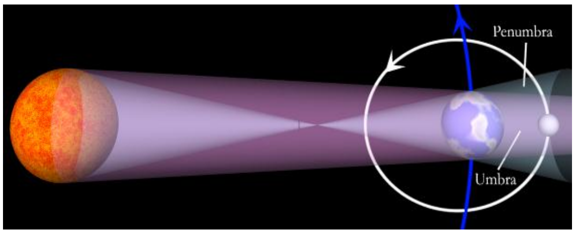
Inference(s)

6. **(a)** Look at the picture below, observe carefully about the position of sun, moon and earth. Write inferences based on your observations.



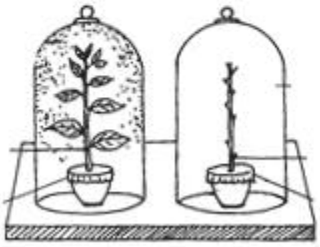
Inference(s)

(b). Look at the picture below. Observe carefully about the position of sun, earth and moon. Write inference(s) based on your observations.



Inference(s)

7. Look at the picture of bell jar experiment. Observe the differences between two jars. What do you infer by observing these two jars?

Observation	Inference(s)
	

8. Observe the experiment. Different liquids such as kerosene, castor oil, diesel, water and honey are kept separately.10 ml of each liquid added into a beaker. Observe the floatation of liquids in water, based on observations write inferences.

[Floatation of liquid experiment performed by students for observation and inferences]

Inference(s)

9. Observe the experiment; inflated balloon kept above the lighted candle observe what happened. Another inflated balloon containing some amount of water kept over the lighted candle. Observe carefully and write valid inferences based on your observation.

[As shown in the picture below, experiment was demonstrated for making inferences]

Inference(s)

10. Look at simple pendulum experiment with the length of 50, 60 and 70 cm respectively. Oscillate the string and note down the time taken for 20 oscillations in different length mentioned above. Write inferences based on observations.

S.No	Length of pendulum (Metal bob)	Time taken for 20 Oscillations
1.	50 cm	
2.	60 cm	
3.	70 cm	

Inference(s)
I infer that

11. Take some ice cubes or ice water in a steel tumbler. Observe the water drops surround the tumbler outside and write inferences based on the presence of water drops outside the tumbler.

[Students taken some of the ice cubes crystal in a tumbler and observed the water drops outside the tumbler, based on their observations students written inferences]

12. Observe the following demonstration of experiment, after completion of experiment write inference based on your observation.

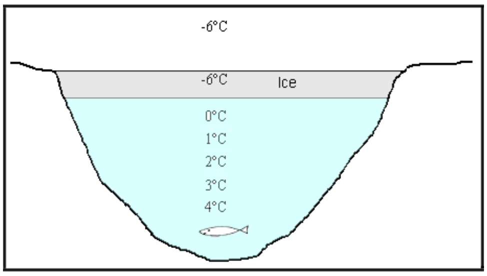
[Researcher demonstrated the experiment: Small amount of sodium hydroxide taken in a test tube and added two drops of phenolphthalein indicator. Students observed the pink coloured solution in the test tube. Afterwards, small amount of dilute hydrochloric acid added into the test tube, students observed the disappearance of colour. Based on this experiment students asked to write inferences]

13. Look at the table, there are different substances such as petrol, melting of lighted candle and burning camphor. Observe carefully 5 minutes about the changes of states. After your keen observation write inferences below.

[Students observed that petrol was taken in a china dish and kept open, a candle was lighted, and a piece of camphor was fired. After observation students written inferences]

Inferences

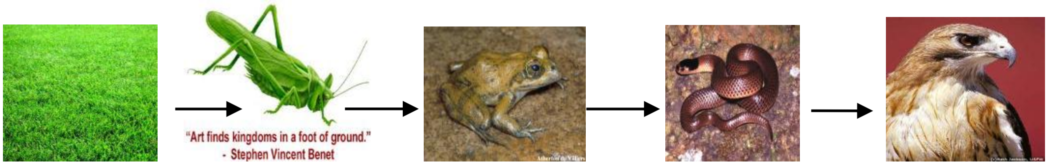
14. Look at the frozen pond pictures; observe the temperature of water from bottom to top. What do you infer from this picture?



Inference(s)

15. The following sequence of pictures giving detail about in a paddy field, there may exist of different variety of organisms and they eat each other to survive. Observe the picture and what do you infer from this pictures?

Grass Grasshopper Frog Snake Hawk



Inference(s)

16. Watch the prerecorded experiment on different types of levers displayed on the computer. After the completion of video write your inferences below.

[Prerecorded experiment on different types of levers played for observation and inferences].

APPENDIX_2.1

RUBRIC FOR OBSERVATION SKILL

Name of the Student : **Medium:** English

Standard **:** VIII **School** **:** GHSS, Gudalur

Item No	Parameters of observation Skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1	Similarities and difference between plant cell and animal cell	Not observed any similarities and differences with respect to cell shape, cell wall, cell organelles. Observation was irrelevant and incorrect.	Observed very few similarities and differences with respect to cell shape, cell wall, cell organelles, but most of the observation is incorrect, incomplete.	Almost observed similarities and differences with respect to cell shape, cell wall, cell organelles correctly. But not complete.	All similarities and difference with respect to cell shape, cell wall, and cell organelles observed completely, correctly and relevantly.
2	Observation of pencil and coin in a glass with water	Not observed anything relevant to pencil and coin in the water. Observation was irrelevant and incorrect.	Very few observations made correctly, and most of the observations are incorrect, incomplete and irrelevant.	Almost made correct and relevant observations but not complete, few observations are incomplete and incorrect.	All observations are complete, correct and relevant with respect to coin and pencil in a glass of water.
3	Observation of flame lighted candle	Observations are irrelevant and incorrect.	Very few observations made correctly and relevantly. Most of the observations are incorrect incomplete and irrelevant.	Observations are almost correct and relevant. But few observations are incomplete and incorrect.	Observations are correct and complete with respect to different zones of flame, shape, smoke and wick.
4	Similarities and differences between parenchyma and sclerenchyma cell	Not observed any similarities and differences. Also observations are irrelevant and incorrect.	Very few similarities and differences observed correctly and relevantly. Most of the observations are in correct, irrelevant and incomplete.	Almost observed similarities and differences with respect to cell shape, cell wall, cell vacuole etc. But few observations are missing, incorrect and incomplete.	Observed all similarities and differences with respect to cell shape, cell wall, cell vacuole etc correctly and completely.

5	Observation of ginger and potato	Observations are irrelevant and incorrect. Not observed any differences correctly and relevantly.	Very few observations are correct and relevant. Most of the observations are irrelevant, incorrect and incomplete.	Observations are almost correct and relevant with respect to colour, shape, smell etc. And few Observations are incorrect and incomplete.	All observations with respect to the shape, colour, smell etc. correct complete and relevant.
6	Observation of decayed bread	Observation was irrelevant and incorrect with respect to colour, smell and appearance of decayed bread.	Very few observations made correctly and relevantly with respect to colour, smell and appearance. But most of the observations are incorrect, irrelevant and incomplete.	Almost observed correctly and relevantly. But few observations are incorrect incomplete and irrelevant.	Made all observations (smell, colour, appearance etc)correctly, relevantly and completely through senses.
7	Observing the mercury level in the thermometer kept in water.	Unable to observe the raise of mercury in the thermometer. Made incorrect observation on mercury.	Observed the level of mercury in the thermometer but written observation was much higher than or lower than accurate.	Observed the level of mercury in the thermometer with minute error.	Observed the level of mercury correctly and accurately in the thermometer.
8	Observation of preserved Centipede specimen.	Observation is irrelevant and incorrect, and not observed any morphological characteristics of centipede.	Very few morphological characteristics are observed. Most of the observations are incorrect, irrelevant and incomplete.	Almost observed the morphological characteristics correctly and relevantly but few observations are incorrect, incomplete and irrelevant.	All morphological characteristics are observed correctly, relevantly and completely.
9	Observation of Chemicals.	Not observed the taste, smell, appearance and texture of chemicals correctly accurately. Made incorrect or incomplete observations.	Very few observations are correct, appropriate and accurate. Most of the observations are incomplete and incorrect.	Observations are almost correct and complete but few of the observations are incomplete, incorrect.	Taste, smell, appearance, texture of chemicals observed correctly, relevantly, completely and accurately.

10	Listens audio on Saturn planet.	Not listened the audio of Saturn planet correctly, relevantly.	Listens only very few information on Saturn planet correctly, accurately and relevantly but most of the observations are incorrect and incomplete.	Almost correctly and accurately listened but few of the information not listened correctly and completely.	All the information on Saturn Planet listens correctly, keenly accurately and completely.
11	Observation of Human Blood tissue slide in microscope.	Observed incorrect and irrelevant information's of Human blood tissue.	Very few observations are noticed correctly and relevantly but most of the observations are incorrect, irrelevant.	Observations are almost correct about Human blood tissue but few observations are incorrect, irrelevant and	All the observation on Human blood tissue is correct, relevant and complete.
12	Observation of aquatic succession picture.	Not observed any differences correctly, relevantly completely about picture.	Very few differences observed correctly and relevantly. Most of the observations are missed, incorrect, irrelevant, incomplete.	Differences almost observed correctly and relevantly but few observations are incorrect, incomplete and irrelevant.	Observed all the differences correctly, completely and relevantly.
13	Observation of sand.	Observation of mixture of sand is Incorrect, irrelevant and incomplete.	Very few observations made correctly, relevantly but most of the observations are incomplete, irrelevant and incorrect.	Observations in almost correct and complete but few observations are incorrect, irrelevant and incomplete.	All observations are correct, complete and relevant.
14	Observing the picture of beaker, trough, and the scale.	All the observations are incorrect and incomplete.	Very few observations are correct and complete, and rest of the observations are incorrect and irrelevant.	Observations are almost correct and complete but few observations are incorrect and incomplete.	All observations made correctly completely with regard to picture.
15	Observation of preserved spider specimen.	Not observed any morphological characteristics, observations are incorrect and irrelevant.	Very few morphological characteristics observed correctly but most of the observations are incorrect, irrelevant and incomplete.	Morphological characteristics almost observed correctly but very few observations are incorrect, irrelevant and incomplete.	All the morphological characteristics observed correctly and completely.
16	Observation of a plant (real specimen)	Observed incorrect morphological characteristics stem, root and leaf of plant.	Very few observations of stem, root, and leaf are correct, and most of the observations are incorrect.	Observation of root, stem and leaf is almost correct, and very few observations are missed and incorrect.	Observation on root stem and leaf was correct, relevant and complete.

APPENDIX_2.2

RUBRIC FOR CLASSIFICATION SKILL

Name of the Student: **Medium: English**

Standard :VIII **School : GHSS, Gudalur**

Item No	Parameters of Classification Skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1.	Classifying into conductors and insulators	Not at all classified the objects into conductors and insulators correctly based on similarities.	Very few objects were correctly classified into conductors and insulators based on similarities but most of the objects classified wrongly and incompletely.	Most of the objects were Classified into conductors and insulators based on some similarities but few objects are not classified correctly and completely.	Classified all the objects into conductors and insulators correctly and completely based on certain similarities.
2.	Classifying into magnetic and non magnetic substances	Not at all correctly classified the objects into magnetic and non magnetic substances based on force of attraction of objects by magnets.	Few objects are correctly classified into magnetic and non magnetic substances based on force of attraction of objects by magnets, but most of the objects are classified incorrectly and incompletely.	Most of the objects are classified into magnetic and non magnetic substances correctly based on force of attraction of objects by magnets. Few objects are classified incorrectly.	All the objects are classified into magnetic and non magnetic substances correctly and completely based on similarities and differences.
3	Classifying the animals based on common attributes.	Not at all correctly classified the animals into different categories based on similar attributes or similarities and differences.	Very few animals are categorised correctly with reasons based on similar attributes or similarities and differences, but most of the animals are not/ or wrongly classified based on similar attributes.	Most of the animals are classified correctly with proper reasons based on similar attributes, but few animals are classified incorrectly.	All the animals are classified correctly with proper reasons based on similar attributes or similarities and difference.

4.	Classified into solids liquids and gases.	Not at all correctly classified the materials / substances into solids, liquid and gas based on similarities.	Very few materials/ substances are classified correctly based on similarities, but most of materials/ substances classified incorrectly.	Most of the materials/ substances classified correctly based on similarities, but few are not classified correctly.	Classified all the materials/ substances correctly and completely on based on similar features.
5.	Classify into pure, impure, opaque, and transparent substances.	Not at all classified correctly based on common features.	Very few substances/objects are classified correctly based on similarities. Few are not/ incorrectly classified based on the resemblances.	Most of the substances/ objects are classified correctly based similarities. Few substances/ objects are not/ incorrectly classified.	All the substances/ objects are classified correctly completely based on similarities.
6.	Classifying the materials/ substances into metals and non metals	Not at all correctly classified the materials/ substances into metals and non metals based on similarities and differences.	Very few materials/ substances are classified correctly based on similarities and differences. Most of the materials and substances are not/incorrectly classified.	Most of the materials/ substance are classified into metals and non metals based on similarities and differences. Few are not/ Incorrectly classified based on similarities.	All the materials/substances are classified into metals and non metals correctly and completely.
7.	Classifying the plants into hydrophytes, mesophytes and xerophytes.	Not at all correctly classified the plants into hydrophytes, mesophytes and xerophytes correctly based on the habitat.	Very few plants are classified correctly based on their habitat. Most of the plants are classified incorrectly/ not classified.	Most of the plants are classified correctly based on their habitat. Few plants are classified wrongly/ not classified.	All the plants are classified correctly and completely based on their habitat.
8.	Classifying the animals into aerial, arboreal and cave animals.	Not at all correctly classified the animals correctly based on their habitat.	Very few animals are classified correctly based on their habitat. Most of the animals are wrongly classified.	Most of the animals are classified correctly based on habitat. Few animals incorrectly classified.	All the animals are classified correctly and completely based on their place of living.
9.	Classifying the materials/substances into transparent, translucent and opaque.	Not at all correctly classified based on similarities and differences.	Very few materials/ substances are classified correctly based on the similarities and differences but most of the materials/substance classified incorrectly.	Most of the materials/ substances are classified correctly based on their similarities and differences but few incorrectly classified	All the materials/substances are classified correctly and completely based on similarities and differences.

10.	Classifying the animals into herbivores, carnivores and omnivores	No animals are correctly classified based on the food the animals eat.	Very few animals classified correctly based on the food they eat, but most of the animals are incorrectly classified.	Most of the animals are classified correctly based the food they eat. Few animals are incorrectly classified.	All the animals classified correctly and completely based on the food they eat.
11..	Classifying into soluble, insoluble and slightly soluble substances in water.	No substances are correctly classified into soluble, insoluble and slightly soluble substances in water based on similarities and differences.	Very few substances are correctly classified into soluble, insoluble and slightly soluble substances in water based on similarities and differences, but most of substances classified incorrectly.	Most of the substances are correctly classified into soluble and insoluble and slightly soluble substances in water based on similarities and differences. Few substances incorrectly classified.	All the substances are correctly and completely classified based on similarities and differences.
12.	Classifying the organisms into unicellular and multicellular.	No organisms are correctly classified into unicellular and multicellular based on number of cells in their body.	Very few organisms are correctly classified into unicellular and multicellular based on number of cells in their body. Most of organisms incorrectly classified.	Most of the organisms are correctly classified into unicellular and multicellular based on number of cells in their body, but few organisms are wrongly classified.	All the organisms are correctly and completely classified into unicellular and multicellular.
13.	Classifying the organisms into reptiles and amphibians.	No organisms are correctly classified into reptiles and amphibians based on similarities and differences	Very few organisms are correctly classified based on similarities and differences, but most of the animals incorrectly classified.	Most of the animals are correctly classified into reptiles and amphibians based on similarities and differences, but few animals classification is incorrect.	All the animals are correctly classified into reptiles and amphibians based on similarities and differences.
14.	Classifying the animals into vertebrates and invertebrates based on presence and absence of backbone.	No animals are correctly classified into vertebrates and invertebrates based on the presence and absence of back bone.	Very few animals are correctly classified into vertebrates and invertebrates based on the presence and absence of back bone, but most of the animals incorrectly classified.	Most of the animals are classified correctly into vertebrates and invertebrates, but few animals are incorrectly classified.	All the animals are correctly classified into vertebrates and invertebrates based on the presence and absence of back bone.

15.	Classifying the substances/ chemicals into acids and bases based on charact-eristics of acids and bases.	No substances/ chemicals are correctly classified into acids and bases based on characteristics of acids and bases.	Very few substances/ chemicals are correctly classified into acids and bases, but most of the substances/ chemicals are classified incorrectly.	Most of the substances/chemicals are classified into acids and bases but few are wrongly classified.	All the substances/chemicals are correctly, classified into acids and bases based on characteristics of acids and bases.
16.	Classifying the material into first order, second order and third order levers based on position of load, effort and fulcrum.	Not at all correctly classified the simple machines into first order, second order and third order levers based on the position of load, effort and fulcrum.	Few of the simple machines correctly classified into first order, second order and third order, but most of the materials are incorrectly classified.	Most of the materials are correctly into first order, second order and third order levers, but few machines not classified correctly	All the materials are classified correctly, completely based on the position of load, effort and fulcrum.
17.	Classifying the food materials into pulses and cereals	Not at all classified the food materials correctly based on the similarities.	Very few food materials are correctly classified into pulses and cereals based on the similarities, but most of the materials are not classified correctly.	Most of the food materials are correctly classified into cereals and pulses based on similarities but few materials classified wrongly.	All the given food materials are correctly and completely classified into pulses and cereals based on the similarities.
18.	Classifying the fruits into dry and fleshy fruits	No fruits are correctly classified into dry and fleshy fruits based on the similarities.	Very few fruits are correctly classified into dry and fleshy fruits, and most of the fruits incorrectly classified.	Most of the fruits are correctly classified into dry and fleshy fruits based on the similarities but few fruits are classified wrongly.	All the fruits are correctly and completely classified into dry and fleshy fruits based on the similarities.

APPENDIX_2.3

RUBRIC FOR COMMUNICATION SKILL

Name of the Student: **Medium:** English

Standard **:** VIII **School** **:** GHSS, Gudalur

Item No	Parameters of Communication skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1	Drawing a line graph for velocity versus time	Not written the title, X axis and Y axis. Graph plotted incorrectly and inappropriately.	Written title of the graph, X axis and Y axis for velocity versus time but plotted the graph incorrectly and inappropriately.	Written title of the graph, X axis and Y axis for velocity versus time, and plotted line graph was almost correct, complete.	Plotted graph correctly, completely and appropriately with title, X axis and Y axis for velocity verses time.
2	Draw bar graph for requirements of calorific value for adults (male and female) with respect to their age.	Not written title of the graph, X axis and Y axis. Drew bar graph incorrectly, inappropriately and incompletely.	Written title of the bar graph, X axis and Y axis. Drew bar graph but incorrect, incomplete inappropriate.	Written title of the bar graph, X axis and Y axis. Bar graph was almost correct but not completely correct.	Bar diagram drew correctly, completely and appropriately with title, and X axis and Y axis.
3	Write name of the different electric component corresponding to the symbols	Not correctly written names of the electric component corresponding to symbols.	Very few electric component names corresponding to symbols written correctly. Most of the electric component names written incorrectly.	Most of the electric component names corresponding to symbols written correctly. Few of the names written incorrectly.	All the electric component names corresponding to symbols written correctly and completely.

4	Draw arrow mark to show flow of energy from sun to different organisms, and among the organisms.	Drew incorrect arrow mark to show energy flow from sun to different organisms, and among the organisms.	Drew correct arrow mark to show energy flow from sun to different organisms, but drew incorrect arrow mark among one organism to other organisms.	Drew correct arrow mark to show flow of energy from sun to different organisms, but drew arrow mark among the organisms was partially correct and complete.	Drew arrow mark from sun to organisms and among one organism to other organisms correctly and completely.
5	Draw the arrow mark to show the food web among the different organisms.	Drew incorrect arrow mark to show the food web between different organisms.	Very few arrow marks between different organisms drew correctly to show the food web, but most of the arrow mark drew incorrectly and irrelevantly.	Most of the arrow mark between different organisms drew correctly to show the food web, but few arrow marks drew incorrectly and irrelevantly.	All the arrow marks between different organisms drew correctly and completely to show the food web among the different organisms.
6	Draw line graph for uniform speed verses time.	Not written the title of the graph, X axis and Y axis for uniform speed verses time. Plotted line graph is incorrect irrelevant.	Written title of graph, X axis and Y axis for speed verses time, but plotted line graph was incorrect and irrelevant.	Written title of the graph, X axis and Y axis for uniform speed verses time but plotted line graph was almost correct but not completely correct.	Plotted line graph is correct and complete with title, X axis and Y axis for speed verses time.
7	Draw line graph for non uniform speed verses time.	Not written title of the line graph, X axis and Y axis for non uniform speed versus time. Plotted line graph was incorrect irrelevant.	Written title of line graph, X axis and Y axis for non uniform speed versus time, but plotted line graph was incorrect and irrelevant.	Written title of the graph, X axis and Y axis for non uniform speed versus time but plotted graph was almost correct but not completely correct.	Plotted line graph is correct and complete with title, X axis and Y axis for non uniform speed versus time.
8	Write name of elements corresponding to Pictorial symbols.	Not at all correctly written any of the elements names corresponding to Pictorial symbols.	Very few elements names corresponding to pictorial symbol written correctly. But most of the elements name not written correctly.	Most of the elements names corresponding to pictorial symbol written correctly, but few elements name incorrectly written.	All the elements names corresponding to pictorial symbol written correctly and completely.

9	Draw pie chart to show percentage of atmospheric gases.	Not at all drew pie chart to show percentage of atmospheric gases, also not written the percentage of different gases.	Drew pie chart incorrectly and irrelevantly to show percentage of atmospheric gases; and not written percentage of each gas correctly.	Drew pie chart is partially correct and complete, and written percentage of gases partially correct.	Drew pie chart was correct and complete, and written percentage of gases correctly.
10	Draw the diagram of Human heart.	Drew diagram is incomplete, unclear and not labelled any of the parts correctly.	Drew diagram is correct but not labelled the parts correctly.	Drew diagram is correct and complete, and labelled the parts incompletely.	Drew diagram is correct and complete, and labelled all the parts correctly.
11	Write name of the elements corresponding to symbol.	Very few elements name corresponding to the symbol written correctly, but almost all the elements name written incorrectly.	Half of the elements name corresponding to the symbol written correctly, and remaining half of the elements name written incorrectly or not written.	Most of the elements name corresponding to the symbol written correctly, few elements name written incorrectly or not written.	All the elements name corresponding to the symbol written correctly and completely.
12	Draw the diagram of Human brain.	Drew diagram was incorrect, incomplete and unclear, and not labelled the parts.	Drew diagram is correct and complete, but not labelled the parts correctly.	Drew diagram was correct, complete, clear, and labelled the parts incompletely.	Drew diagram was correct, clear and complete, and labelled all the parts correctly.
13	Write different stages of metamorphosis of insects.	Different stages of metamorphosis of insects not written correctly, completely and orderly. And not described about the same correctly.	Few stages of metamorphosis of insect identified and written correctly and sequentially. And most of the stages not identified and Described.	Most of the stages Identified and written correctly sequentially. But few stages are not identified and described correctly.	Identified all the stages of insects, and written Correctly.
14	Draw the tabular column to show Life span of different organisms.	Drew incorrect and inappropriate tabular column and written life span of few animals and plants incorrectly and incompletely.	Drew incorrect and inappropriate tabular column and written life span of plants and animals correctly.	Drew correct and appropriate tabular column and written life span of animals and plants correctly.	Drew correct, complete and tabular column and written life span of all plants and animals systematically.

15	Writing Chemical formula for chemical reaction.	Not written any formula for reactants and product of chemical reaction.	Few chemical formulas for reactants and products written correctly, but most of the chemical formulas written incorrectly.	Most of the formulas for reactants and products written correctly, and few chemical formulas written incorrect.	All the chemical formulas in chemical reaction written correctly and completely.
16	Write steps of tissue culture technique.	Steps of tissue culture technique was not written and not described correctly.	Steps of tissue culture technique was written correctly and completely but not described.	Steps of tissue culture technique written correctly and completely but description is incomplete.	Each Steps of tissue culture technique written and described correctly and completely.

APPENDIX_2.4

RUBRIC FOR MEASUREMENT SKILL

Name of the Student: **Medium:** English
Standard **:** VIII **School:** GHSS, Gudalur

Item No	Parameters of Measurement Skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1.	Measure the length, breadth of rectangle diagram.	Length and breadth measured incorrectly thus written measurements are much higher than accurate and precise.	Length and breadth measurements not accurate but very closer to precise and accurate.	Any one (length or breadth) measured correctly, precisely and accurately. But not both the measurement correct and precise.	Both length and breadth measurement is correct, precise and accurate.
2.	Measure the base and height of the triangle diagram.	Base and height of triangle diagram measured incorrectly thus measurement is much higher than precise and accurate.	Measured height and base of triangle diagram is not accurate but very closer to precise and accurate.	Any one (base or height) measured correctly, precisely and accurately. But not both the measurement is precise and accurate.	Base and length of triangle diagram measured correctly, precisely and accurately.
3.	Measurement of exact amount of water in measuring cylinder.	Quantity of water measured in the graduated cylinder was much higher or lower than accurate and precise.	Quantity of water measured in the graduated cylinder was slightly less or slightly more than the accurate and precise.	Quantity of water measured in the graduated cylinder was apparently correct, precise and accurate but found lower or upper meniscus	Quantity of water measured in the graduated cylinder was precise and accurate.
4.	Measure the length, breadth and height of the cuboids diagram.	Length, breadth and height of cuboids diagram not correctly measured or measurement is much higher than the accurate and precise.	Measured length/breadth/and height of the cuboids very nearer to accurate and precise.	Length/breadth/ height of the cuboids measured correctly, precisely and accurately but not all the measurement is accurate and precise.	Length, breadth and height of the cuboids measured accurately and precisely.

5.	Measure the angles between two joined lines of diagram one and two.	Measured angles between two lines are incorrect and inappropriate thus measurement was much higher than precise and accurate in both the diagrams. And not written measurement unit.	Correctly measured the angle between two lines but measurement is slightly higher or lower than accurate and precise in both the diagrams and written measurement with unit correctly.	One diagram angle between two lines measured accurately and precisely, but the other diagram angle was incorrect and inaccurate. And unit of measurement written correctly for both the angles.	Measured angle between two lines accurate and precise in both the diagrams, and written with correct measurement unit.
6.	Measure the total area of leaf (irregular object)with the help of graph sheet.	Outline of leaf drew incorrectly on the graph sheet, and incorrectly measured total area of leaf, thus measurement is inaccurate.	Outline of leaf drew correctly on the graph sheet, and incorrectly measured total area of leaf. Thus measurement was inaccurate and imprecise.	Outline of leaf drew correctly on the graph sheet, and total area of leaf measured correctly but the measurement is not accurate and precise.	Outline of leaf drew correctly on the graph sheet, and total area of leaf measured and written accurately and precisely
7.	Measure the mass of the object using pointer balance.	Student incorrectly weighed the mass of an object, thus the measurement was much higher or lower than accurate and precise.	Student weighed the mass of an object correctly but the measurement is not precise and accurate. Measurement was slightly higher or lower than accurate and precise.	Student correctly weighed the mass of an object, and the measurement is apparently correct, precise, but not accurate.	Student correctly weighed the mass of an object, and the same written precisely and accurately.
8.	Measure the temperature of hot water and cold water using thermometer.	Temperature of hot water and cold water measured incorrectly, inaccurately, also written without measurement unit.	Temperature of hot water and cold water measured incorrectly, inaccurately and the same written with measurement unit.	Any one water temperature (hot water or temp cold water) measured correctly, accurately and precisely. And the same written with correct measurement unit.	Temperature of hot water and cold water measured correctly, precisely and accurately, and the same written with correct measurement unit.

9.	Measure the length, breadth and height of the table using measurement.	Length, breadth and height of the table measured incorrectly, thus written measurement imprecise and inaccurate. Also not written measurement unit.	Length, breadth and height of the table measured somewhat correctly; written measurement was closer to precise and accurate. Written correct measurement unit.	Breadth and height of the table measured correctly and accurately but length of the table measured incorrectly.	Length, breadth and height of the table measured correctly, accurately and precisely. And written correct measurement unit.
10.	Determine the volume of irregular object (Stone) by displacement of water.	Not at all followed correct procedure to determine volume of irregular stone thus determined volume of stone is incorrect and inaccurate. Also not written measurement unit.	To some extent followed correct procedure to determine volume of irregular stone, but exact volume of stone not determined by the student, thus the volume of stone is incorrect and inaccurate. Also not written measurement unit	Almost followed the correct procedure to measure and determine the volume of stone, and the volume of stone nearer to precise and accurate and the same written with measurement unit.	Correct procedure followed to determine the volume of stone, and the same precisely and accurately determined. Also written with measurement unit.
11.	Measure the length of the pendulum and time period for oscillations.	Length of the pendulum and time period of oscillation measured Incorrectly thus measurement is imprecise and inaccurate. Also not written measurement unit correctly.	Length of pendulum measured incorrectly but written with correct measurement unit. Time period of oscillations measured and written incorrectly.	Length of pendulum measured correctly, and the measurement is accurate and precise, and the same written with measurement unit. But time period of oscillation is incorrect, inaccurate and imprecise, written without measurement unit.	Measured the length of pendulum and time period of oscillation correctly, accurately and precisely. And written with measurement unit.

12.	Measure the length and breadth of cloth.	Measured the length and breadth of cloth, but measurement is not accurate and precise. And the same written without measurement unit.	Measured the length and breadth of cloth correctly to some extent, and the same written with measurement unit.	Measured length and breadth of the cloth nearer to correct and accurate, and the same written correct measurement unit.	Length and breadth measurements are correct and accurate. And the same written with unit.
13.	Measuring $KMnO_4$solution in graduated beaker from burette fixed on a stand.	Volume of $KMnO_4$ solution collected in the graduated beaker from burette was much higher or lower than accurate and precise.	Volume of $KMnO_4$ solution collected in the graduated beaker from the burette was slightly higher or lower than precise and accurate.	Volume of $KMnO_4$ solution collected in the graduated beaker from burette was apparently precise and accurate (i.e. lower or higher meniscus).	Volume of $KMnO_4$ solution taken precisely and accurately in the graduated beaker from burette.
14.	Pipette out 20 ml of water from beaker.	Pipette out water from beaker is much higher or lower than accurate and precise (20ml).	Pipette out water from beaker was slightly higher or lower than accurate and precise (20ml).	Pipette out 20 ml of water from beaker with lower or higher meniscus thus measurement is nearer to accurate and precise.	Pipette out water exactly20 ml thus measurement is accurate and precise.
15.	Measure the thickness of book and calculate thickness of one page.	Thickness of book measured incorrectly and inappropriately thus thickness of one page was incorrect, inaccurate and imprecise. And not written measurement unit.	Thickness of book measured correctly but thickness of one page incorrectly measured, thus measurement was partially correct and precise.	Thickness of book measured correctly, and thickness of one page calculated correctly which was closer to accurate and precise.	Thickness of book and thickness of one page measured correctly, accurately and precisely.

16.	Measuring the temperature of classroom in Celsius and Fahrenheit scale.	Temperature of classroom measured by Celsius and Fahrenheit scale, but measured temp is incorrect, imprecise and inaccurate.	Temperature of classroom measured by Celsius and Fahrenheit scale is closer to correct, accurate and precise.	Temperature of classroom measured correctly and accurately either by Celsius scale or Fahrenheit scale not in both.	Temperature of classroom measured by Celsius and Fahrenheit scale correctly, accurately and precisely.
17.	Measure the Length of curved line diagram with the help of thread	Student incorrectly used the thread to measure length of curved line diagram, thus measurement was incorrect and imprecise.	Student somewhat correctly used the thread to measure length of curved line diagram but the measurement was incorrect and imprecise.	Student almost correctly used the thread to measure the curved line diagram, thus measurement is closer to correct and accurate.	Student correctly used thread to measure the curved line, thus measurement was correct and accurate.
18.	Measure the length, breadth of post card	Measured length and breadth of post card is slightly higher or lower than Accurate and precise, and the same not written with measurement unit	Measured length and breadth of post card is closer to precise and accurate and written the same with measurement unit	Measured length breadth of post card is correct and accurate. But the same not written with measurement unit	Length and breadth of post card measured correctly, precise and accurately. And the same written with measurement unit.

APPENDIX_2.5

RUBRIC FOR PREDICTION SKILL

Name of the Student: **Medium:** English

Standard: VIII **School:** GHSS, Gudalur

Item No	Parameters of Prediction Skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1.	Prediction on (a) Floating or sinking of ice cubes in water. (b) Change of water level during melting of ice.	(a) Predicted incorrectly and given incorrect reason or not given reasons for prediction. (b) Predicted incorrectly and not given any reasons or given reasons is incorrect	Predicted correctly but reason for prediction is incorrect or not written any reason. Predicted correctly but reason for prediction is incorrect or not written reason	Predicted correctly and written reason for prediction is partially correct and complete. Predicted correctly and reason for prediction is partially correct and complete.	Predicted correctly and reasons for prediction also correct and complete. Predicted correctly and reasons for prediction also correct and complete.
2.	Prediction on time taken for number of oscillations at different length of the pendulum.	Predicted incorrectly and reasons for prediction was incorrect and irrelevant, or not given any reasons.	Some of the predictions are correct, but given reasons is incorrect and irrelevant, or not given any reasons.	Most of the predictions are correct, and written reasons are partially correct and complete.	Almost all predictions are correct and written reasons are correct and complete.
3.	Prediction on floatation of different liquids such kerosene, castor oil, honey and diesel in water.	Predicted incorrectly on order of floatation of different liquids in water and written incorrect and irrelevant reasons or no reasons.	Prediction on order of floatation of liquids in water is partially correct, and given reasons for prediction is irrelevant and incorrect or not written any reasons.	Prediction on order of floatation of liquids in water is almost correct, and reason for prediction was partially correct and complete.	Prediction on order of floatation of liquids in water is correct and reason for prediction was correct and complete.
	Prediction on Floating or sinking	All the three Predictions are incorrect and reasons	One of the predictions is correct and written	Two of the predictions are correct, and reason for	All the three prediction are correct, and reasons

4.	of egg (i) in water, (ii) salt solution and (iii) vinegar.	for prediction are incorrect and irrelevant or not written reasons.	reasons are incorrect or partially correct or not written any reasons.	predictions is incorrect or partially correct or not written any reasons.	for predictions are correct and complete.
5.	Predict the angle between two joined plane mirrors at different trials.	None of the predictions on angles between two joined plane mirrors are incorrect, and written reasons are incorrect or not written any reasons. .	Few of the predictions on angles between two joined mirrors are correct and written correct reasons or partially correct or not written any reasons.	Most of the predictions on angles between two joined mirrors are correct, and given correct reasons or partially correct or not written any reasons	All the predictions on angles between two joined plane mirrors are correct and written correct reasons for predictions.
6.	Prediction on floating or sinking of tomato, brinjal, erasers, pencil and paraffin wax in water and kerosene.	None of the predictions with respect to sinking or floating of different objects are correct. And reasons for predictions are incorrect and or not written.	Few of the predictions with respect to sinking or floating of different objects are correct, and reasons for predictions are incorrect or partially correct or not written.	Most of the predictions with respect to sinking or floating of different objects are correct, and reasons for predictions are incorrect or partially correct or not written.	All the predictions with respect to sinking or floating of different objects are correct, and reasons for predictions are correct and complete.
7.	Prediction on temp of hot water and cold water.	Predicted temperature of hot water and cold water was much higher or lower than correct temperature.	Predicted temperature of hot water or cold water or both slightly higher or lower than accurate temperature.	Predicted temperature of hot water or cold water or both very nearer to accurate temperature.	Predicted temperature of hot water or cold water or both almost correct and accurate temp.
8.	Prediction on fast dissolving substances in water (crystal sugar or crystal salt or jaggery).	Prediction is incorrect and reason for prediction was incorrect or not written any reasons.	Prediction is correct and written reasons are incorrect or not written any reason.	Prediction is correct and reason for prediction was partially correct and complete.	Predicted correctly and written reasons for prediction was also correct and complete.

9.	Prediction on miscibility and immiscibility of liquids such as coconut oil, kerosene, petrol and honey in water.	None of the predictions are correct and written reasons for prediction are incorrect or not written any reasons.	Few predictions are correct but reasons are incorrect or not written reasons. But most of the predictions and reasons are incorrect.	Most of the predictions are correct and written reasons are correct or partially correct. But few predictions and reasons are incorrect.	All the predictions are correct and written reasons are correct or partially correct.
10.	Prediction on osmosis (thistle funnel experiment).	Prediction is incorrect and reason for prediction was incorrect or not written any reason.	Prediction is correct and the given reason was incorrect or not written any reason.	Predicted correctly and written reason was partially correct.	Predicted correctly and given reason for prediction was correct.
11.	Predict: seed germination faster in soil + fertilizer or soil + manure.	Prediction is incorrect and written reason was incorrect or not written any reasons.	Predicted correctly and written incorrect reasons or not written any reason.	Predicted correctly and reasons for prediction was partially correct.	Predicted correctly and reason for prediction also correct and proper.
12.	Predict: melting of ice faster in which places/ substances.(cold water, Dark place, Salt solution, Sugar solution).	Predicted incorrectly and given incorrect reasons or not written any reason.	Predicted correctly but given reasons are incorrect or not written any reason.	Predicted correctly and given reason is partially correct.	Predicted correctly and given correct and appropriate reason.
13.	Predict: Decreasing of temperature faster in which vessel (aluminium, brass etc).	Predicted incorrectly and written reason is incorrect or not written any reason for prediction.	Predicted correctly and written incorrect reason or not written any reasons for prediction.	Predicted correctly and written partially correct reasons for prediction.	Predicted correctly and written correct reasons for prediction.

14.	Predict: evaporation faster in petrol or water.	Prediction is incorrect and written incorrect reason or not written reason.	Predicted correctly and written reason was incorrect or not written reason.	Predicted correctly but reason for prediction is partially correct.	Predicted correctly and written correct reason for prediction.
15.	Predict about rain	Prediction is incorrect and written incorrect reason or not written reason.	Prediction is correct but written reason was incorrect or not written reason.	Predicted correctly and reason for prediction was partially correct.	Predicted correctly with correct and appropriate reasons.
16.	Predict about a leaf with worm.	None of the predictions are correct, or not written any prediction	Few predictions are correct and most of the predictions are incorrect.	Most of the predictions are correct and few predictions are incorrect.	Student made more number of Predictions correctly based on the observation.

APPENDIX_2.6

RUBRIC FOR INFERENCE SKILL

Name of the Student: **Medium:** English

Standard: VIII **School:** GHSS, Gudalur

Item. No	Parameters of Inference Skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1	Inference based on observation of melting of ice cubes in thistle funnel with thermometer.	Written merely few observations but inference was irrelevant and incorrect.	Somewhat inference is relevant and correct but not complete.	Inference(s) is/are almost correct and relevant but incomplete	Derived inference(s) is/are correct and relevant based on observations.
2	Inference on photosynthesis.	Written just observations about plant picture, not written any inference correctly.	Somewhat inference is relevant, correct , but incomplete.	Inference is almost correct and relevant, but incomplete.	Inferred correctly, completely and clearly based on observations.
3	Inference on Soluble and insoluble substances in water.	Written only observations but inference was not derived or incorrect derived.	Somewhat inference is relevant and correct, but not completely correct.	Written inference is almost correct, but not completely correct.	Inference derived was correctly and completely based on observations.
4	Inference based on acid and base test.	Written all observations correctly but written inference is incorrect and irrelevant.	To some extent inference was relevant and correct, but not complete.	Inference was almost relevant and correct but incomplete inference(s).	Inferred correctly, completely and clearly based on observation of acid base test.
5	Inference on transfer of heat in solid (Experimentation in iron rod)	Written observations are correct but not derived any inference correctly.	To some extent inference was relevant and correct, but not complete.	Inference was almost relevant and correct but incomplete inference.	Derived inference was correct and complete based on observations.

6	(a) Inference on solar eclipse and (b) Inference on lunar eclipse	Written just position of sun, earth and moon by looking the picture but written inference was irrelevant, incorrect or not written any inference.	To some extent written inference is relevant, clear and correct but not completely derived inference.	Written inference is almost correct and relevant but incomplete.	Inferred correctly, completely based on observations.
7	Inference on transpiration	Written observations are correct but inference is irrelevant and incorrect.	To some extent inference is relevant, correct but not complete	Inference is almost relevant, correct but incomplete.	Written inference is correct, complete and clear based on observations.
8	Inference based on floatation of different liquids such as kerosene, castor oil, diesel and honey in water.	Written merely observations but inference was irrelevant, incorrect.	Inference was somewhat relevant and correct but not complete.	Inference was almost correct and clear but incomplete.	Inference made correctly completely and clearly based on observations.
9	Inference based on experiment on absorption of heat by empty inflated balloon, &absorption of heat by inflated balloon with water when brought over the lighted candle.	Observations made correctly but inference derived incorrectly, unclearly and irrelevantly.	To some extent inference was relevant correct, but complete.	Almost written inference was correct and clear, but incomplete.	Written inference was correct, clear and complete based on observations.
10	Inference based on time period for oscillations in different lengths (Simple pendulum experiment).	Observation written correctly but inference was incorrect and irrelevant.	Inference is somewhat relevant and correct, but incomplete.	Inference was almost correct, relevant and clear, but incomplete.	Based on observations student Inferred correctly, completely and clearly.
11	Inference based on observations of water droplets outside the steel tumbler with ice cubes inside.	Written observations are correct but inference was incorrect and irrelevant.	To some extent inference was correct, clear and relevant.	Inference is almost correct, clear and complete.	Inference is correct, complete and clear based on observations.
12	Inference based on observation of experiment on neutralisation of acid base test.	Observations written correctly but Inference was incorrect, unclear and irrelevant.	Somewhat inference was correct, clear and relevant. But not complete.	Inference was almost correct and clear, but incomplete.	Inference was correct, clear and complete based on observations.

13	Inference on change of states of matter experiment (Melting, Sublimation and Vaporisation)	Observations are correct but Inference is incorrect, unclear and irrelevant.	To some extent inference was correct relevant but not complete.	Inference was almost correct, clear and complete.	Written inference was correct, clear and complete based on observations.
14	Inference on anomalous expansion of water in pond	Written some observations from by seeing the picture but inference was incorrect, unclear and irrelevant.	To some extent inference was correct, clear, and relevant.	Inference is almost correct, and clear, but not complete.	Inference is correct, complete and clear based on observations.
15	Inference on food Chain	Written observations are correct but inference was incorrect, unclear and irrelevant.	To some extent Inference was correct, and relevant but incomplete inference.	Inference is almost correct, clear and relevant.	Inference is correct, clear and relevant based on observations.
16	Inference on different types of levers	Written observations are correct but inference was incorrect, unclear and irrelevant.	To some extent Inference was correct, and relevant but incomplete.	Inference is almost correct, clear and relevant.	Inference is correct, clear and relevant based on observations.

APPENDIX_3.1

Close Ended Questionnaire for Basic Science Process Skills

Name of the Student : **Std: VIII**
School : **Time: 30 Min**

Choose the correct answer

Q.1) when we make statement based on observations or experience about what will happen in future.

A. Observation **B.** Defining operationally
C. Communication **D.** Predicting

Q.2) when we make a representation of an object or an idea by verbal or non-verbal.

A. Making models **B.** Predicting
C. Classifying **D.** Communicating

Q.3) when we employ one or more of our 5 senses to collect informations about an object or an event or things called.

A. Communicating **B.** Inferring
C. Observing **D.** Classifying

Q.4) when we quantify the things or liquids using standardized units.

A. Investigating **B.** Measuring
C. Predicting **D.** Calculating

Q.5) when we create definitions or conclusions based on thorough observations.

A. Making models **B.** Inferring
C. Classifying **D.** Observing

Q.6) When we sorting the things/objects based on the common characteristics or certain similar features

A. Communicating **B.** Measuring
C. Classifying **D.** Defining operationally

Q.7) when we convey information through charts, graphs, tables and lab reports

A. Measurement **B.** Making models
C. Communication **D.** Classifying

Q.8) when we test a prediction by doing experiment and collected data and results shared to others

A. Communicating **B.** Measurement
C. Observing **D.** Investigating

Q.9) when we use the following devices such as vernier caliber and screw guage to find out the radius and diameter of marbles and a thread.

A. Measurement
B. Formula
C. Calculation
D. Inference

Q.10) While doing simple pendulum experiment the following skill(s) will be employed

A. Observation and classification
B. Measurement
C. Communication and observation
D. Observation, measurement, communication and inference

Q.11) if we guess based on observation what will happen next

A. Measurement
B. Inferring
C. Predicting
D. Observing

Q.12) Determining the length, width, area, volume, weight, mass, volume or temperatures to quantify objects or liquids

A. Observing
B. Measuring
C. Communicating
D. Inferring

Q.13) Placing the objects or things or substances into different groups/category based on some common characteristics or attributes.

A. Observing
B. Classifying
C. Inferring
D. Measuring

Q.14) Describe about an object or event or observations to another person

A. Controlling variables
B. Presenting data
C. Communicating
D. Inferring

Q.15) Deriving a conclusion about an object or event after observations

A. Inferring
B. Experimenting
C. Observing
D. Communicating

Q.16) When we noticing or identifying the differences between similar objects or pictures

A. Inference
B. Experimenting
C. Communication
D. Observation

Q.17) When we identifying the similarities between the different objects or events or pictures

A. Inference
B. Measurement
C. Observation
D. Communication

Q.18) When we noticing the keen details through senses that are very relevant to an investigation or experimentation called

A. Observation
B. Defining Operationally
C. Inference
D. Classification

Q. 19) When we examine the events or objects or specimens using the magnifying lens called

A. Notification | **B.** Observation
C. Monitoring | **D.** Inference

Q.20) We employ our tongue or nose to identify the taste and smell called

A. Inference | **B.** Observation
C. Communication | **D.** Inference

Q.21) When we use speech or written our ideas and observation or linking one ideas with other

A. Communication | **B.** Classification
C. Inference | **D.** Speaking

Q.22) When we hear/listen to others ideas/ opinions and responding to them.

A. Inference | **B.** Speaking
C. Communication | **D.** Observation

Q.23) When we take notes about an event or an experiment while others doing science demonstration or while watching television or computer called.

A. Experimentation | **B.** Demonstration
C. Listening | **D.** Communication

Q. 24) When we use various science models or specimens or apparatus and explain to others

A. Communication | **B.** Classification
C. Simulation | **D.** Inference

Q.25) When we use graphs, symbols, flowchart, pie diagrams, tables and bar diagram in science to display the data.

A. Measurement | **B.** Communication
C. Inference | **D.** Classification

Q.26) We use appropriate standard units in making comparisons or for taking reading is

A. Observing | **B.** Measurement
C. Observation | **D.** Prediction

Q.27) We use suitable instrument or device for finding/checking the accuracy of diameter or radius.

A. Observation | **B.** Comparisons
C. Measurement | **D.** Calculations

Q.28) When we make a forecast about what will happen in the future based on observation or prior knowledge gained through experience or collected data is

A. Assumptions | **B.** Prediction
C. Conclusions | **D.** Classification

Q.29) We make our keen observations quantitatively by using conventional standard units

B. Calculation
A. Measurement
C. Prediction
D. Computation

Q.30) When we use thermometer to find out the temperature of water or temperature of room or laboratory is

A. Prediction
B. Calculations
C. Measurement
D. Inference

Q.31) When we use graduated cylinder for what?

A. Measuring
B. Transfer the liquid
C. Reading
D. Observing

Q.32) When we use puppets and burette for what?

A. Inferring
B. Communicating
C. Measuring
D. Computing

Q.33) When we sorting the materials or organisms or objects based some common features or characteristics

A. Communications
B. Classification
C. Inference
D. Measurement

Q.34) When we grouping or arranging the materials or substances or things based on some common similarities and differences

A. Observation
B. Predicting
C. Classification
D. Inference

Q.35) When we find out the mass, weight, volume, area, speed, length and breadth is

A. Measurement
B. Inference
C. Observations
D. Prediction

APPENDIX_4.1

Rating Scale for Basic Science Process Skills

School: GHSS, Gudalur **Medium: English**

Standard: VIII **Time : 60 Minutes**

[Put Tick Mark whichever you feel Correct]

Item No	Statements	Always	Some times	Most of the time	Never
Observation Skill					
1.	I have observed the important events in science experiment				
2.	I use to observe / notice the similarities and differences of science diagrams				
3.	I have used the magnifying lens during my observations				
4.	I have observed the living insects / leech / earthworm etc in science				
5.	I have used my sensory organs such as nose, ear and tongue during my observations.				
6.	I have observed the smell of some chemicals/ substances in science class				
7.	I have touched some of the chemicals to find out the texture				
8.	I was asked to hear / listen the science experiment audio in the television/ computer				
9.	I have seen the microscope and operated while observing the specimens				
10.	I have observed the slides in the microscope				
11.	I have observed the science experiment/ demonstration performed by the teacher or by other student				
12.	I have observed the various preserved specimens of animals/ insects/ plants kept in the laboratory				
13.	I have observed the science experiment in the multimedia theatre/ projector				
Classification Skill					
14.	I have classified the objects / materials based on their similarities and differences in science				
15.	I have classified the objects / materials into smaller and bigger based on their size				
16.	I have classified the substances / materials into magnetic and non magnetic				
17.	I have classified the substances or materials into solids, liquids and gases during practical.				

Item No	Statements	Always	Some times	Most of the time	Never
18.	I have classified the substances / chemicals into acids and bases				
19.	I have classified the materials into rough, smooth and plain surfaces				
20.	I have classified materials / substances into conductors of electricity and insulators				
21.	I have classified materials / substances into good conductors of heat and poor conductors of heat				
22.	I have classified the organisms into birds, reptiles, amphibians and insects while observing the organisms in the environment				
23.	I have classified various elements into metals and non metals				
24.	I have classified the materials into transparent , translucent and opaque				
25.	I have classified the organisms into herbivore, carnivores and omnivores				
26.	I have classified the chemical substances into soluble and in soluble				
27.	I have classified the animals into vertebrates and invertebrates				
28.	I have classified the animals into unicellular and multicellular organisms				
29.	I have classified the plants into xerophytes, mesophytes and hydrophytes				
30.	I have seen different types of levers and I classified them into first order, second order and third order levers				
Communication Skill					
31	After completion of science experiment/ demonstration. I have discussed with other students about the same				
32.	When I was discussing with other students, i have used scientific terms				
33.	I asked many questions to teachers during experimentations				
34.	I have presented my observations and inference in the class after the experiments				
35.	I have submitted the written report about the science experiment				
36.	I have drawn the line graph, bar graph and pie chart in science class				
37.	I have prepared the tables, charts and posters in science class				

Item No	Statements	Always	Some times	Most of the time	Never
38.	I use to take notes during the demonstration of experiment				
39.	I have drawn the diagrams and labelled clearly by observing the science models/ charts				
40.	I was asked to read the text book in science class				
41.	I use to write chemical formula while writing the chemical equation				
42.	I use to draw simple flow chart in science				
43.	I was engaged in group discussion in science				
44.	Food chain, food web and energy flow, I have represented by picture/ diagrams				
45.	I have measured the length/ breadth and width of the object				
Measurement Skill					
46.	I have measured the thickness of wire or diameter of wire using the screw gauge				
47.	I have measured the temperature of hot water or cold water using the thermometer				
48.	I have measured the length of the pendulum				
49.	In simple pendulum experiment, I have counted the time taken for 20 (Different numbers of)oscillations in different lengths				
50.	I have used the pointer balance / spring balance to weigh the object				
51.	I have used the measuring cylinder to measure the exact quantity of water or chemical solutions				
52.	I have used the pipette and burette to measure the exact quantity of water or chemical solutions				
53.	I have measured the volumes of irregular objects using the displacement method of water				
54.	I have measured the total area of irregular leaf/ objects using the graph sheet				
Prediction Skill					
55.	I have predicted what will happen in future during the science demonstration/ experiment				
56.	I have predicted the forecasting events when other students performing the experiments				
57.	Before performing the experiment, I have made predictions about the future event.				

Item No	Statements	Always	Some times	Most of the time	Never
Inference Skill					
58.	I have written my own inference based on the several observations of experiment				
59.	I have discussed with friends about the experiment and derived inference by own				
60.	My teacher demonstrated the science experiment but inference I have written by own				

APPENDIX_5.1

Semi Structured Interview for Students of Standard VIII (before Intervention Programme)

The following semi structured questions were asked during focus group interview with students before implementation of intervention programme and further probed to draw out more information.

- What are Science Process Skills?
- Did your science teacher teach about science process skills earlier?
- Did you visit laboratory, and have you ever engaged in doing experiments by your own either in the laboratory or classroom?
- Did you ever operate microscope for observing the specimens?
- Did you use magnifying lens for observing the fine details which are not able to see through our eyes?
- Have you done simple pendulum experiments by your own?
- Have you touched, smelled, observed the chemicals?
- Did you measure water or liquids with the help of pipette or burette in the science class?
- Did you observe plant and animal specimens in laboratory?
- Whether your science teacher demonstrated any experiments to enhance Process Skills?
- What was the teaching method followed by the teacher in earlier classes?
- Did you classify the things, objects, materials, substances based on similarities and differences?
- Have you plotted graph, bar diagram, tables, pie chart for the given data; or do you know the symbols for chemical elements, symbol for electrical components?
- Have you measured the length, breadth, height, temperature using appropriate devices?
- Have you made any attempt to write inference by your own?

APPENDIX_5.2

Semi Structured Interview for Students of Standard VIII (after Intervention Programme)

The following semi structured questions were asked during focus group interview with students after implementation of intervention programme and further probed to draw out more information.

- What are the types of science process skills?
- Which are the Process Skills you acquired through Intervention Programme?
- How did you learn science during the period of intervention programme?
- Does all the experiments and activities included in the programme was appropriate to your cognitive abilities?
- Did you like experiential learning method of teaching?
- Which are the sensory organs you employed while observation?
- Can you able to measure length, breadth, height, weight, temperature using suitable instrument?
- Can you able to classify the objects, things, substances based on similarities and differences?
- Can you able to draw table, graph, and pie chart if data is given?
- How will you predict about the forecasting events or occurrences?
- Can you able to derive inference based on observations of experiments, pictures?

APPENDIX_5.3

Semi Structured Interview for non-sampled Students (after Intervention Programme)

The following questions were asked to students who were not sample for the present study (VIII standard Tamil medium). The questions were asked after completion of intervention programme to know about their status of process skills.

- Do you know about science Process Skills?
- Have you ever studied Science Process Skills and its types?
- Did you operate microscope and simple pendulum?
- Did you use hand lens for observation?
- Have you seen thermometer and burette?
- Did you measure length, breadth, height, and temperature, mass during the science class?
- Do you know to classify the things according to similarities and differences?
- Can you draw tables, graph, and pie chart in science?
- How will you predict about the future events or occurrences?
- Can you able to write inferences based on observations?

APPENDIX_5.4

Semi Structured Interview for Parents and Siblings ((after Intervention Programme)

Following semi structured interview questions were asked with parents after intervention programme and further probed.

- Did your child discuss about how was the science teaching in standard eight?
- Did your child discussed about hands on experiences and role play in science?
- What method of teaching learning you would like to suggest teachers to teach science?
  - Lecture method or hands on experience method?
- Did your child discuss about laboratory visit and hands on experiences in science?
- Did your child discuss about method of science teaching? And did your child share about handling science apparatus such as simple pendulum hand lens and chemicals etc?
- Did your child discuss about how do they observe, classify, measure etc?

APPENDIX_6.1

List of experts Validated the Tools and Intervention Programme

Prof. Manjula P. Rao Regional Institute of Education Mysore, NCERT Manju882002@yahoo.com.	Prof. V.D Bhatt Regional Institute of Education Mysore NCERT Karnataka. bhatvd@yahoo.com
Prof. Lakshminarayan Regional Institute of Education Mysore, NCERT undurthy@gmail.com	Prof. S Kumar (Rtd) Department of Education, CASE Faculty of Education and Psychology The M S University of Baroda Vadodara
Prof. R.G. Kothari Department of Education, CASE Faculty of Education and Psychology The M S University of Baroda Vadodara. rgkothari@yahoo.com.	Prof. R.S. Mani Department of Education, CASE Faculty of Education and Psychology The M S University of Baroda Vadodara
Prof. D. R. Goel (Rtd) Department of Education, CASE Faculty of Education and Psychology The M S University of Baroda Vadodara. Goel_d_34@rediffmail.com	Prof. Ashutosh Biswal Department of Education, CASE Faculty of Education and Psychology The M S University of Baroda Vadodara
Dr. A. Ramachary Assistant Director, QETP Oxford Educational Institution Oxford Public School, Kadivali West Mumbai. archary@gmail.com	Prof. H.O. Joshi (Rtd) Head, Dept of Education Sourastra University Rajkot, Gujarat hojoshi2002@yahoo.com
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Dr. Asha D Kamath Regional Institute of Education Mysore, NCERT ashakamathrie@rediffmail.com	Prof. S.P. Malhotra (Rtd) Professor in Education Kurukshetra University, Kurukshetra
Dr, Shashi Vanzari Head, Dept of Education Nagpur University	Prof. Bharat Joshi Department of Education Gujarat Vidyapeeth, Ahmadabad

APPENDIX_ 7.1

PERMISSION LETTER FOR DATA COLLECTION

From:
Ramesh M
UGC Research Scholar,
Centre of Advanced Study in Education,
Faculty of Education and Psychology,
The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat
Date: 6.5.11

Through Proper Channel

To,
The Chief Educational Officer,
Nilgiri district,
Udhagamandalam, Tamilnadu.

Subject: Permission for data collection

Respected Sir,
Greetings!
I am doing Ph.D. on ***"Acquisition of Science Process skills through Experiential Learning among Students of Standard VIII"*** under the guidance of Dr. R. C. Patel, Reader in Education, (CASE), Faculty of Education and Psychology, The M S University of Baroda, Vadodara. As a part of my study, I need to collect the data from one of the schools following Tamilnadu State Board Syllabus. Based on all practical aspects like; facilities available, expected cooperation and nearness of school from my residence, I would like to undertake my study in Gudalur Government Higher Secondary School, Gudalur Taluka of Nilgiri district. I assure you that I will be handling science subject among the students of standard VIII for almost one full academic year (2011-2012) and shall fulfill all the requirements of completing syllabus, helping in assessment of students and other normal duties in the school.

In this connection, may I request your kind self to grant me the permission to carry out my Ph. D. work in the above stated school?

With Kind Regards!
Thanking you in anticipation of positive response.
Yours faithfully,
6.5.11
Ramesh M

Dr. R. C. Patel
Guide
Reader in Education
Centre of Advanced Study in Education
Faculty of Education & Psychology
The M. S. University of Baroda

Prof. S. C. Panigrahi
Head, CASE
Centre of Advanced Study in Education
Department of Education
Faculty of Education & Psychology

Prof. D. R. Goel
Dean
DEAN
FACULTY OF EDUCATION & PSYCHOLOGY
M. S. UNIVERSITY OF BARODA
VADODARA

Copy to
1. **The DEO, Gudalur Taluka, Nilgiri district, Tamilnadu**
2. **The Head Master, Gudalur Higher Secondary School, Gudalur, Nilgiris.**

APPENDIX_ 7.2

CERTIFICATE FROM SCHOOL HEAD MASTER

From

The Head master
Govt Hr Sec School
Gudalur

To

Whom soever it may concerned

Respected sir

This is to certify that Ramesh M, Ph D student of Dr R.C Patel, reader in Education, Faculty of Education and Psychology (CASE) The Maharaja Sayajirao University of Baroda, Gujarat. As a researcher he experimented the strategy (Experiential learning) in students of standard VIII throughout the academic year of 2011 – 2012 for developing Science process skills. During the period of experimentation, researcher sincerely followed the school regularity and timings, he stayed full school hours for implementing the strategy and engaging the students in science experiments, I also came to know from students and teachers that the students acquired process skills through this method of teaching (Experiential learning).

Thanking you

By

9-4-12

HEAD MASTER
Govt. Hr Sec School

Place: Gudalur, The Nilgiris

Date: April 2012

APPENDIX_ 8.1

COURSEWORK CERTIFICATE

सत्यं शिवं सुन्दरम्

THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

CERTIFICATE

[As per O.Ph.D. 2 under UGC (Minimum Standards and Procedure for Awards of M.Phil./Ph.D. Degree) Regulation, 2009 for 15 Credits to be earned by Ph.D. Scholars]

This is to certify that **Mr.Ramesh M,** Research Scholar, registered under UGC (*Minimum Standards and Procedure for Awards of M.Phil./Ph.D. Degree) Regulation, 2009,* vide Registration Certificate Number **484** dated **12/3/2010**, for pursuing Ph.D. on has undertaken and completed the course work with the **Grade A.**

STATEMENT OF CREDITS EARNED

Name of Research Scholar: **Mr. Ramesh M** *(M)*

Faculty/Institution: Faculty of Education & Psychology

Department: Education

Paper Number	Course Title	Course Credits	Grade Earned
Core Courses – 09 Credits *[Offered At University Level]*			
I.	Introduction to Research & Research Writings	3	B
II.	Introduction to Basic Computer Functions & Application for Research Purposes	3	B
III.	Quantitative Research Techniques & Data Analysis	3	B
Departmental Courses – 06 Credits *[Offered at Departmental Level]*			
IV.	Review of Related Literature	3	A
V.	Conceptual Framework	3	A
		Overall Grade	**A**

ACA3/5

Date of Issue: 02/05/2013

Place: Vadodara

Registrar (OSD)

Grade Conversion Table and Grade Calculation Formula

Grade	Grade Points	Range
O	10	Above 9.01
A	9	8.01 – 9.00
B	8	7.01 – 8.00
C	7	6.01 – 7.00
D	6	5.01 – 6.00
E	5	4.01 – 5.00
F	4	Below 4.00

$$Overall\ Grade = \frac{\sum (Grade\ Points \times Credits)}{\sum Credits}$$

APPENDIX_9.1

Gudalur Government Higher Secondary School, Gudalur The Nilgiris

APPENDIX_2.1

RUBRIC FOR OBSERVATION SKILL

Name of the Student : **Medium:** English

Standard **:** VIII **School** **:** GHSS, Gudalur

Item No	**Parameters of observation Skill**	**Beginning Stage**	**Developing Stage**	**Accomplished Stage**	**Proficient Stage**
1	Similarities and difference between plant cell and animal cell	Not observed any similarities and differences with respect to cell shape, cell wall, cell organelles. Observation was irrelevant and incorrect.	Observed very few similarities and differences with respect to cell shape, cell wall, cell organelles, but most of the observation is incorrect, incomplete.	Almost observed similarities and differences with respect to cell shape, cell wall, cell organelles correctly. But not complete.	All similarities and difference with respect to cell shape, cell wall, and cell organelles observed completely, correctly and relevantly.
2	Observation of pencil and coin in a glass with water	Not observed anything relevant to pencil and coin in the water. Observation was irrelevant and incorrect.	Very few observations made correctly, and most of the observations are incorrect, incomplete and irrelevant.	Almost made correct and relevant observations but not complete, few observations are incomplete and incorrect.	All observations are complete, correct and relevant with respect to coin and pencil in a glass of water.
3	Observation of flame lighted candle	Observations are irrelevant and incorrect.	Very few observations made correctly and relevantly. Most of the observations are incorrect incomplete and irrelevant.	Observations are almost correct and relevant. But few observations are incomplete and incorrect.	Observations are correct and complete with respect to different zones of flame, shape, smoke and wick.
4	Similarities and differences between parenchyma and sclerenchyma cell	Not observed any similarities and differences. Also observations are irrelevant and incorrect.	Very few similarities and differences observed correctly and relevantly. Most of the observations are in correct, irrelevant and incomplete.	Almost observed similarities and differences with respect to cell shape, cell wall, cell vacuole etc. But few observations are missing, incorrect and incomplete.	Observed all similarities and differences with respect to cell shape, cell wall, cell vacuole etc correctly and completely.

5	Observation of ginger and potato	Observations are irrelevant and incorrect. Not observed any differences correctly and relevantly.	Very few observations are correct and relevant. Most of the observations are irrelevant, incorrect and incomplete.	Observations are almost correct and relevant with respect to colour, shape, smell etc. And few Observations are incorrect and incomplete.	All observations with respect to the shape, colour, smell etc. correct complete and relevant.
6	Observation of decayed bread	Observation was irrelevant and incorrect with respect to colour, smell and appearance of decayed bread.	Very few observations made correctly and relevantly with respect to colour, smell and appearance. But most of the observations are incorrect, irrelevant and incomplete.	Almost observed correctly and relevantly. But few observations are incorrect incomplete and irrelevant.	Made all observations (smell, colour, appearance etc)correctly, relevantly and completely through senses.
7	Observing the mercury level in the thermometer kept in water.	Unable to observe the raise of mercury in the thermometer. Made incorrect observation on mercury.	Observed the level of mercury in the thermometer but written observation was much higher than or lower than accurate.	Observed the level of mercury in the thermometer with minute error.	Observed the level of mercury correctly and accurately in the thermometer.
8	Observation of preserved Centipede specimen.	Observation is irrelevant and incorrect, and not observed any morphological characteristics of centipede.	Very few morphological characteristics are observed. Most of the observations are incorrect, irrelevant and incomplete.	Almost observed the morphological characteristics correctly and relevantly but few observations are incorrect, incomplete and irrelevant.	All morphological characteristics are observed correctly, relevantly and completely.
9	Observation of Chemicals.	Not observed the taste, smell, appearance and texture of chemicals correctly accurately. Made incorrect or incomplete observations.	Very few observations are correct, appropriate and accurate. Most of the observations are incomplete and incorrect.	Observations are almost correct and complete but few of the observations are incomplete, incorrect.	Taste, smell, appearance, texture of chemicals observed correctly, relevantly, completely and accurately.

10	Listens audio on Saturn planet.	Not listened the audio of Saturn planet correctly, relevantly.	Listens only very few information on Saturn planet correctly, accurately and relevantly but most of the observations are incorrect and incomplete.	Almost correctly and accurately listened but few of the information not listened correctly and completely.	All the information on Saturn Planet listens correctly, keenly accurately and completely.
11	Observation of Human Blood tissue slide in microscope.	Observed incorrect and irrelevant information's of Human blood tissue.	Very few observations are noticed correctly and relevantly but most of the observations are incorrect, irrelevant.	Observations are almost correct about Human blood tissue but few observations are incorrect, irrelevant and	All the observation on Human blood tissue is correct, relevant and complete.
12	Observation of aquatic succession picture.	Not observed any differences correctly, relevantly completely about picture.	Very few differences observed correctly and relevantly. Most of the observations are missed, incorrect, irrelevant, incomplete.	Differences almost observed correctly and relevantly but few observations are incorrect, incomplete and irrelevant.	Observed all the differences correctly, completely and relevantly.
13	Observation of sand.	Observation of mixture of sand is Incorrect, irrelevant and incomplete.	Very few observations made correctly, relevantly but most of the observations are incomplete, irrelevant and incorrect.	Observations in almost correct and complete but few observations are incorrect, irrelevant and incomplete.	All observations are correct, complete and relevant.
14	Observing the picture of beaker, trough, and the scale.	All the observations are incorrect and incomplete.	Very few observations are correct and complete, and rest of the observations are incorrect and irrelevant.	Observations are almost correct and complete but few observations are incorrect and incomplete.	All observations made correctly completely with regard to picture.
15	Observation of preserved spider specimen.	Not observed any morphological characteristics, observations are incorrect and irrelevant.	Very few morphological characteristics observed correctly but most of the observations are incorrect, irrelevant and incomplete.	Morphological characteristics almost observed correctly but very few observations are incorrect, irrelevant and incomplete.	All the morphological characteristics observed correctly and completely.
16	Observation of a plant (real specimen)	Observed incorrect morphological characteristics stem, root and leaf of plant.	Very few observations of stem, root, and leaf are correct, and most of the observations are incorrect.	Observation of root, stem and leaf is almost correct, and very few observations are missed and incorrect.	Observation on root stem and leaf was correct, relevant and complete.

APPENDIX_2.2

RUBRIC FOR CLASSIFICATION SKILL

Name of the Student: **Medium: English**

Standard :VIII **School : GHSS, Gudalur**

Item No	Parameters of Classification Skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1.	Classifying into conductors and insulators	Not at all classified the objects into conductors and insulators correctly based on similarities.	Very few objects were correctly classified into conductors and insulators based on similarities but most of the objects classified wrongly and incompletely.	Most of the objects were Classified into conductors and insulators based on some similarities but few objects are not classified correctly and completely.	Classified all the objects into conductors and insulators correctly and completely based on certain similarities.
2.	Classifying into magnetic and non magnetic substances	Not at all correctly classified the objects into magnetic and non magnetic substances based on force of attraction of objects by magnets.	Few objects are correctly classified into magnetic and non magnetic substances based on force of attraction of objects by magnets, but most of the objects are classified incorrectly and incompletely.	Most of the objects are classified into magnetic and non magnetic substances correctly based on force of attraction of objects by magnets. Few objects are classified incorrectly.	All the objects are classified into magnetic and non magnetic substances correctly and completely based on similarities and differences.
3	Classifying the animals based on common attributes.	Not at all correctly classified the animals into different categories based on similar attributes or similarities and differences.	Very few animals are categorised correctly with reasons based on similar attributes or similarities and differences, but most of the animals are not/ or wrongly classified based on similar attributes.	Most of the animals are classified correctly with proper reasons based on similar attributes, but few animals are classified incorrectly.	All the animals are classified correctly with proper reasons based on similar attributes or similarities and difference.

4.	Classified into solids liquids and gases.	Not at all correctly classified the materials / substances into solids, liquid and gas based on similarities.	Very few materials/ substances are classified correctly based on similarities, but most of materials/ substances classified incorrectly.	Most of the materials/ substances classified correctly based on similarities, but few are not classified correctly.	Classified all the materials/ substances correctly and completely on based on similar features.
5.	Classify into pure, impure, opaque, and transparent substances.	Not at all classified correctly based on common features.	Very few substances/objects are classified correctly based on similarities. Few are not/ incorrectly classified based on the resemblances.	Most of the substances/ objects are classified correctly based similarities. Few substances/ objects are not/ incorrectly classified.	All the substances/ objects are classified correctly completely based on similarities.
6.	Classifying the materials/ substances into metals and non metals	Not at all correctly classified the materials/ substances into metals and non metals based on similarities and differences.	Very few materials/ substances are classified correctly based on similarities and differences. Most of the materials and substances are not/incorrectly classified.	Most of the materials/ substance are classified into metals and non metals based on similarities and differences. Few are not/ Incorrectly classified based on similarities.	All the materials/substances are classified into metals and non metals correctly and completely.
7.	Classifying the plants into hydrophytes, mesophytes and xerophytes.	Not at all correctly classified the plants into hydrophytes, mesophytes and xerophytes correctly based on the habitat.	Very few plants are classified correctly based on their habitat. Most of the plants are classified incorrectly/ not classified.	Most of the plants are classified correctly based on their habitat. Few plants are classified wrongly/ not classified.	All the plants are classified correctly and completely based on their habitat.
8.	Classifying the animals into aerial, arboreal and cave animals.	Not at all correctly classified the animals correctly based on their habitat.	Very few animals are classified correctly based on their habitat. Most of the animals are wrongly classified.	Most of the animals are classified correctly based on habitat. Few animals incorrectly classified.	All the animals are classified correctly and completely based on their place of living.
9.	Classifying the materials/substance s into transparent, translucent and opaque.	Not at all correctly classified based on similarities and differences.	Very few materials/ substances are classified correctly based on the similarities and differences but most of the materials/substance classified incorrectly.	Most of the materials/ substances are classified correctly based on their similarities and differences but few incorrectly classified	All the materials/substances are classified correctly and completely based on similarities and differences.

10.	Classifying the animals into herbivores, carnivores and omnivores	No animals are correctly classified based on the food the animals eat.	Very few animals classified correctly based on the food they eat, but most of the animals are incorrectly classified.	Most of the animals are classified correctly based the food they eat. Few animals are incorrectly classified.	All the animals classified correctly and completely based on the food they eat.
11..	Classifying into soluble, insoluble and slightly soluble substances in water.	No substances are correctly classified into soluble, insoluble and slightly soluble substances in water based on similarities and differences.	Very few substances are correctly classified into soluble, insoluble and slightly soluble substances in water based on similarities and differences, but most of substances classified incorrectly.	Most of the substances are correctly classified into soluble and insoluble and slightly soluble substances in water based on similarities and differences. Few substances incorrectly classified.	All the substances are correctly and completely classified based on similarities and differences.
12.	Classifying the organisms into unicellular and multicellular.	No organisms are correctly classified into unicellular and multicellular based on number of cells in their body.	Very few organisms are correctly classified into unicellular and multicellular based on number of cells in their body. Most of organisms incorrectly classified.	Most of the organisms are correctly classified into unicellular and multicellular based on number of cells in their body, but few organisms are wrongly classified.	All the organisms are correctly and completely classified into unicellular and multicellular.
13.	Classifying the organisms into reptiles and amphibians.	No organisms are correctly classified into reptiles and amphibians based on similarities and differences	Very few organisms are correctly classified based on similarities and differences, but most of the animals incorrectly classified.	Most of the animals are correctly classified into reptiles and amphibians based on similarities and differences, but few animals classification is incorrect.	All the animals are correctly classified into reptiles and amphibians based on similarities and differences.
14.	Classifying the animals into vertebrates and invertebrates based on presence and absence of backbone.	No animals are correctly classified into vertebrates and invertebrates based on the presence and absence of back bone.	Very few animals are correctly classified into vertebrates and invertebrates based on the presence and absence of back bone, but most of the animals incorrectly classified.	Most of the animals are classified correctly into vertebrates and invertebrates, but few animals are incorrectly classified.	All the animals are correctly classified into vertebrates and invertebrates based on the presence and absence of back bone.

15.	Classifying the substances/ chemicals into acids and bases based on charact-eristics of acids and bases.	No substances/ chemicals are correctly classified into acids and bases based on characteristics of acids and bases.	Very few substances/ chemicals are correctly classified into acids and bases, but most of the substances/ chemicals are classified incorrectly.	Most of the substances/chemicals are classified into acids and bases but few are wrongly classified.	All the substances/chemicals are correctly, classified into acids and bases based on characteristics of acids and bases.
16.	Classifying the material into first order, second order and third order levers based on position of load, effort and fulcrum.	Not at all correctly classified the simple machines into first order, second order and third order levers based on the position of load, effort and fulcrum.	Few of the simple machines correctly classified into first order, second order and third order, but most of the materials are incorrectly classified.	Most of the materials are correctly into first order, second order and third order levers, but few machines not classified correctly	All the materials are classified correctly, completely based on the position of load, effort and fulcrum.
17.	Classifying the food materials into pulses and cereals	Not at all classified the food materials correctly based on the similarities.	Very few food materials are correctly classified into pulses and cereals based on the similarities, but most of the materials are not classified correctly.	Most of the food materials are correctly classified into cereals and pulses based on similarities but few materials classified wrongly.	All the given food materials are correctly and completely classified into pulses and cereals based on the similarities.
18.	Classifying the fruits into dry and fleshy fruits	No fruits are correctly classified into dry and fleshy fruits based on the similarities.	Very few fruits are correctly classified into dry and fleshy fruits, and most of the fruits incorrectly classified.	Most of the fruits are correctly classified into dry and fleshy fruits based on the similarities but few fruits are classified wrongly.	All the fruits are correctly and completely classified into dry and fleshy fruits based on the similarities.

APPENDIX_2.3

RUBRIC FOR COMMUNICATION SKILL

Name of the Student: **Medium:** English

Standard **:** VIII **School** **:** GHSS, Gudalur

Item No	Parameters of Communication skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1	Drawing a line graph for velocity versus time	Not written the title, X axis and Y axis. Graph plotted incorrectly and inappropriately.	Written title of the graph, X axis and Y axis for velocity versus time but plotted the graph incorrectly and inappropriately.	Written title of the graph, X axis and Y axis for velocity versus time, and plotted line graph was almost correct, complete.	Plotted graph correctly, completely and appropriately with title, X axis and Y axis for velocity verses time.
2	Draw bar graph for requirements of calorific value for adults (male and female) with respect to their age.	Not written title of the graph, X axis and Y axis. Drew bar graph incorrectly, inappropriately and incompletely.	Written title of the bar graph, X axis and Y axis. Drew bar graph but incorrect, incomplete inappropriate.	Written title of the bar graph, X axis and Y axis. Bar graph was almost correct but not completely correct.	Bar diagram drew correctly, completely and appropriately with title, and X axis and Y axis.
3	Write name of the different electric component corresponding to the symbols	Not correctly written names of the electric component corresponding to symbols.	Very few electric component names corresponding to symbols written correctly. Most of the electric component names written incorrectly.	Most of the electric component names corresponding to symbols written correctly. Few of the names written incorrectly.	All the electric component names corresponding to symbols written correctly and completely.

4	Draw arrow mark to show flow of energy from sun to different organisms, and among the organisms.	Drew incorrect arrow mark to show energy flow from sun to different organisms, and among the organisms.	Drew correct arrow mark to show energy flow from sun to different organisms, but drew incorrect arrow mark among one organism to other organisms.	Drew correct arrow mark to show flow of energy from sun to different organisms, but drew arrow mark among the organisms was partially correct and complete.	Drew arrow mark from sun to organisms and among one organism to other organisms correctly and completely.
5	Draw the arrow mark to show the food web among the different organisms.	Drew incorrect arrow mark to show the food web between different organisms.	Very few arrow marks between different organisms drew correctly to show the food web, but most of the arrow mark drew incorrectly and irrelevantly.	Most of the arrow mark between different organisms drew correctly to show the food web, but few arrow marks drew incorrectly and irrelevantly.	All the arrow marks between different organisms drew correctly and completely to show the food web among the different organisms.
6	Draw line graph for uniform speed verses time.	Not written the title of the graph, X axis and Y axis for uniform speed verses time. Plotted line graph is incorrect irrelevant.	Written title of graph, X axis and Y axis for speed verses time, but plotted line graph was incorrect and irrelevant.	Written title of the graph, X axis and Y axis for uniform speed verses time but plotted line graph was almost correct but not completely correct.	Plotted line graph is correct and complete with title, X axis and Y axis for speed verses time.
7	Draw line graph for non uniform speed verses time.	Not written title of the line graph, X axis and Y axis for non uniform speed versus time. Plotted line graph was incorrect irrelevant.	Written title of line graph, X axis and Y axis for non uniform speed versus time, but plotted line graph was incorrect and irrelevant.	Written title of the graph, X axis and Y axis for non uniform speed versus time but plotted graph was almost correct but not completely correct.	Plotted line graph is correct and complete with title, X axis and Y axis for non uniform speed versus time.
8	Write name of elements corresponding to Pictorial symbols.	Not at all correctly written any of the elements names corresponding to Pictorial symbols.	Very few elements names corresponding to pictorial symbol written correctly. But most of the elements name not written correctly.	Most of the elements names corresponding to pictorial symbol written correctly, but few elements name incorrectly written.	All the elements names corresponding to pictorial symbol written correctly and completely.

9	Draw pie chart to show percentage of atmospheric gases.	Not at all drew pie chart to show percentage of atmospheric gases, also not written the percentage of different gases.	Drew pie chart incorrectly and irrelevantly to show percentage of atmospheric gases; and not written percentage of each gas correctly.	Drew pie chart is partially correct and complete, and written percentage of gases partially correct.	Drew pie chart was correct and complete, and written percentage of gases correctly.
10	Draw the diagram of Human heart.	Drew diagram is incomplete, unclear and not labelled any of the parts correctly.	Drew diagram is correct but not labelled the parts correctly.	Drew diagram is correct and complete, and labelled the parts incompletely.	Drew diagram is correct and complete, and labelled all the parts correctly.
11	Write name of the elements corresponding to symbol.	Very few elements name corresponding to the symbol written correctly, but almost all the elements name written incorrectly.	Half of the elements name corresponding to the symbol written correctly, and remaining half of the elements name written incorrectly or not written.	Most of the elements name corresponding to the symbol written correctly, few elements name written incorrectly or not written.	All the elements name corresponding to the symbol written correctly and completely.
12	Draw the diagram of Human brain.	Drew diagram was incorrect, incomplete and unclear, and not labelled the parts.	Drew diagram is correct and complete, but not labelled the parts correctly.	Drew diagram was correct, complete, clear, and labelled the parts incompletely.	Drew diagram was correct, clear and complete, and labelled all the parts correctly.
13	Write different stages of metamorphosis of insects.	Different stages of metamorphosis of insects not written correctly, completely and orderly. And not described about the same correctly.	Few stages of metamorphosis of insect identified and written correctly and sequentially. And most of the stages not identified and Described.	Most of the stages Identified and written correctly sequentially. But few stages are not identified and described correctly.	Identified all the stages of insects, and written Correctly.
14	Draw the tabular column to show Life span of different organisms.	Drew incorrect and inappropriate tabular column and written life span of few animals and plants incorrectly and incompletely.	Drew incorrect and inappropriate tabular column and written life span of plants and animals correctly.	Drew correct and appropriate tabular column and written life span of animals and plants correctly.	Drew correct, complete and tabular column and written life span of all plants and animals systematically.

15	Writing Chemical formula for chemical reaction.	Not written any formula for reactants and product of chemical reaction.	Few chemical formulas for reactants and products written correctly, but most of the chemical formulas written incorrectly.	Most of the formulas for reactants and products written correctly, and few chemical formulas written incorrect.	All the chemical formulas in chemical reaction written correctly and completely.
16	Write steps of tissue culture technique.	Steps of tissue culture technique was not written and not described correctly.	Steps of tissue culture technique was written correctly and completely but not described.	Steps of tissue culture technique written correctly and completely but description is incomplete.	Each Steps of tissue culture technique written and described correctly and completely.

APPENDIX_2.4

RUBRIC FOR MEASUREMENT SKILL

Name of the Student: **Medium:** English
Standard **:** VIII **School:** GHSS, Gudalur

Item No	Parameters of Measurement Skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1.	Measure the length, breadth of rectangle diagram.	Length and breadth measured incorrectly thus written measurements are much higher than accurate and precise.	Length and breadth measurements not accurate but very closer to precise and accurate.	Any one (length or breadth) measured correctly, precisely and accurately. But not both the measurement correct and precise.	Both length and breadth measurement is correct, precise and accurate.
2.	Measure the base and height of the triangle diagram.	Base and height of triangle diagram measured incorrectly thus measurement is much higher than precise and accurate.	Measured height and base of triangle diagram is not accurate but very closer to precise and accurate.	Any one (base or height) measured correctly, precisely and accurately. But not both the measurement is precise and accurate.	Base and length of triangle diagram measured correctly, precisely and accurately.
3.	Measurement of exact amount of water in measuring cylinder.	Quantity of water measured in the graduated cylinder was much higher or lower than accurate and precise.	Quantity of water measured in the graduated cylinder was slightly less or slightly more than the accurate and precise.	Quantity of water measured in the graduated cylinder was apparently correct, precise and accurate but found lower or upper meniscus	Quantity of water measured in the graduated cylinder was precise and accurate.
4.	Measure the length, breadth and height of the cuboids diagram.	Length, breadth and height of cuboids diagram not correctly measured or measurement is much higher than the accurate and precise.	Measured length/breadth/and height of the cuboids very nearer to accurate and precise.	Length/breadth/ height of the cuboids measured correctly, precisely and accurately but not all the measurement is accurate and precise.	Length, breadth and height of the cuboids measured accurately and precisely.

5.	Measure the angles between two joined lines of diagram one and two.	Measured angles between two lines are incorrect and inappropriate thus measurement was much higher than precise and accurate in both the diagrams. And not written measurement unit.	Correctly measured the angle between two lines but measurement is slightly higher or lower than accurate and precise in both the diagrams and written measurement with unit correctly.	One diagram angle between two lines measured accurately and precisely, but the other diagram angle was incorrect and inaccurate. And unit of measurement written correctly for both the angles.	Measured angle between two lines accurate and precise in both the diagrams, and written with correct measurement unit.
6.	Measure the total area of leaf (irregular object)with the help of graph sheet.	Outline of leaf drew incorrectly on the graph sheet, and incorrectly measured total area of leaf, thus measurement is inaccurate.	Outline of leaf drew correctly on the graph sheet, and incorrectly measured total area of leaf. Thus measurement was inaccurate and imprecise.	Outline of leaf drew correctly on the graph sheet, and total area of leaf measured correctly but the measurement is not accurate and precise.	Outline of leaf drew correctly on the graph sheet, and total area of leaf measured and written accurately and precisely
7.	Measure the mass of the object using pointer balance.	Student incorrectly weighed the mass of an object, thus the measurement was much higher or lower than accurate and precise.	Student weighed the mass of an object correctly but the measurement is not precise and accurate. Measurement was slightly higher or lower than accurate and precise.	Student correctly weighed the mass of an object, and the measurement is apparently correct, precise, but not accurate.	Student correctly weighed the mass of an object, and the same written precisely and accurately.
8.	Measure the temperature of hot water and cold water using thermometer.	Temperature of hot water and cold water measured incorrectly, inaccurately, also written without measurement unit.	Temperature of hot water and cold water measured incorrectly, inaccurately and the same written with measurement unit.	Any one water temperature (hot water or temp cold water) measured correctly, accurately and precisely. And the same written with correct measurement unit.	Temperature of hot water and cold water measured correctly, precisely and accurately, and the same written with correct measurement unit.

9.	Measure the length, breadth and height of the table using measurement.	Length, breadth and height of the table measured incorrectly, thus written measurement imprecise and inaccurate. Also not written measurement unit.	Length, breadth and height of the table measured somewhat correctly; written measurement was closer to precise and accurate. Written correct measurement unit.	Breadth and height of the table measured correctly and accurately but length of the table measured incorrectly.	Length, breadth and height of the table measured correctly, accurately and precisely. And written correct measurement unit.
10.	Determine the volume of irregular object (Stone) by displacement of water.	Not at all followed correct procedure to determine volume of irregular stone thus determined volume of stone is incorrect and inaccurate. Also not written measurement unit.	To some extent followed correct procedure to determine volume of irregular stone, but exact volume of stone not determined by the student, thus the volume of stone is incorrect and inaccurate. Also not written measurement unit	Almost followed the correct procedure to measure and determine the volume of stone, and the volume of stone nearer to precise and accurate and the same written with measurement unit.	Correct procedure followed to determine the volume of stone, and the same precisely and accurately determined. Also written with measurement unit.
11.	Measure the length of the pendulum and time period for oscillations.	Length of the pendulum and time period of oscillation measured Incorrectly thus measurement is imprecise and inaccurate. Also not written measurement unit correctly.	Length of pendulum measured incorrectly but written with correct measurement unit. Time period of oscillations measured and written incorrectly.	Length of pendulum measured correctly, and the measurement is accurate and precise, and the same written with measurement unit. But time period of oscillation is incorrect, inaccurate and imprecise, written without measurement unit.	Measured the length of pendulum and time period of oscillation correctly, accurately and precisely. And written with measurement unit.

12.	Measure the length and breadth of cloth.	Measured the length and breadth of cloth, but measurement is not accurate and precise. And the same written without measurement unit.	Measured the length and breadth of cloth correctly to some extent, and the same written with measurement unit.	Measured length and breadth of the cloth nearer to correct and accurate, and the same written correct measurement unit.	Length and breadth measurements are correct and accurate. And the same written with unit.
13.	Measuring $KMnO_4$solution in graduated beaker from burette fixed on a stand.	Volume of $KMnO_4$ solution collected in the graduated beaker from burette was much higher or lower than accurate and precise.	Volume of $KMnO_4$ solution collected in the graduated beaker from the burette was slightly higher or lower than precise and accurate.	Volume of $KMnO_4$ solution collected in the graduated beaker from burette was apparently precise and accurate (i.e. lower or higher meniscus).	Volume of $KMnO_4$ solution taken precisely and accurately in the graduated beaker from burette.
14.	Pipette out 20 ml of water from beaker.	Pipette out water from beaker is much higher or lower than accurate and precise (20ml).	Pipette out water from beaker was slightly higher or lower than accurate and precise (20ml).	Pipette out 20 ml of water from beaker with lower or higher meniscus thus measurement is nearer to accurate and precise.	Pipette out water exactly20 ml thus measurement is accurate and precise.
15.	Measure the thickness of book and calculate thickness of one page.	Thickness of book measured incorrectly and inappropriately thus thickness of one page was incorrect, inaccurate and imprecise. And not written measurement unit.	Thickness of book measured correctly but thickness of one page incorrectly measured, thus measurement was partially correct and precise.	Thickness of book measured correctly, and thickness of one page calculated correctly which was closer to accurate and precise.	Thickness of book and thickness of one page measured correctly, accurately and precisely.

16.	Measuring the temperature of classroom in Celsius and Fahrenheit scale.	Temperature of classroom measured by Celsius and Fahrenheit scale, but measured temp is incorrect, imprecise and inaccurate.	Temperature of classroom measured by Celsius and Fahrenheit scale is closer to correct, accurate and precise.	Temperature of classroom measured correctly and accurately either by Celsius scale or Fahrenheit scale not in both.	Temperature of classroom measured by Celsius and Fahrenheit scale correctly, accurately and precisely.
17.	Measure the Length of curved line diagram with the help of thread	Student incorrectly used the thread to measure length of curved line diagram, thus measurement was incorrect and imprecise.	Student somewhat correctly used the thread to measure length of curved line diagram but the measurement was incorrect and imprecise.	Student almost correctly used the thread to measure the curved line diagram, thus measurement is closer to correct and accurate.	Student correctly used thread to measure the curved line, thus measurement was correct and accurate.
18.	Measure the length, breadth of post card	Measured length and breadth of post card is slightly higher or lower than Accurate and precise, and the same not written with measurement unit	Measured length and breadth of post card is closer to precise and accurate and written the same with measurement unit	Measured length breadth of post card is correct and accurate. But the same not written with measurement unit	Length and breadth of post card measured correctly, precise and accurately. And the same written with measurement unit.

APPENDIX_2.5

RUBRIC FOR PREDICTION SKILL

Name of the Student: **Medium:** English

Standard: VIII **School:** GHSS, Gudalur

Item No	Parameters of Prediction Skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1.	Prediction on (a) Floating or sinking of ice cubes in water. (b) Change of water level during melting of ice.	(a) Predicted incorrectly and given incorrect reason or not given reasons for prediction. (b) Predicted incorrectly and not given any reasons or given reasons is incorrect	Predicted correctly but reason for prediction is incorrect or not written any reason. Predicted correctly but reason for prediction is incorrect or not written reason	Predicted correctly and written reason for prediction is partially correct and complete. Predicted correctly and reason for prediction is partially correct and complete.	Predicted correctly and reasons for prediction also correct and complete. Predicted correctly and reasons for prediction also correct and complete.
2.	Prediction on time taken for number of oscillations at different length of the pendulum.	Predicted incorrectly and reasons for prediction was incorrect and irrelevant, or not given any reasons.	Some of the predictions are correct, but given reasons is incorrect and irrelevant, or not given any reasons.	Most of the predictions are correct, and written reasons are partially correct and complete.	Almost all predictions are correct and written reasons are correct and complete.
3.	Prediction on floatation of different liquids such kerosene, castor oil, honey and diesel in water.	Predicted incorrectly on order of floatation of different liquids in water and written incorrect and irrelevant reasons or no reasons.	Prediction on order of floatation of liquids in water is partially correct, and given reasons for prediction is irrelevant and incorrect or not written any reasons.	Prediction on order of floatation of liquids in water is almost correct, and reason for prediction was partially correct and complete.	Prediction on order of floatation of liquids in water is correct and reason for prediction was correct and complete.
	Prediction on Floating or sinking	All the three Predictions are incorrect and reasons	One of the predictions is correct and written	Two of the predictions are correct, and reason for	All the three prediction are correct, and reasons

4.	of egg (i) in water, (ii) salt solution and (iii) vinegar.	for prediction are incorrect and irrelevant or not written reasons.	reasons are incorrect or partially correct or not written any reasons.	predictions is incorrect or partially correct or not written any reasons.	for predictions are correct and complete.
5.	Predict the angle between two joined plane mirrors at different trials.	None of the predictions on angles between two joined plane mirrors are incorrect, and written reasons are incorrect or not written any reasons. .	Few of the predictions on angles between two joined mirrors are correct and written correct reasons or partially correct or not written any reasons.	Most of the predictions on angles between two joined mirrors are correct, and given correct reasons or partially correct or not written any reasons	All the predictions on angles between two joined plane mirrors are correct and written correct reasons for predictions.
6.	Prediction on floating or sinking of tomato, brinjal, erasers, pencil and paraffin wax in water and kerosene.	None of the predictions with respect to sinking or floating of different objects are correct. And reasons for predictions are incorrect and or not written.	Few of the predictions with respect to sinking or floating of different objects are correct, and reasons for predictions are incorrect or partially correct or not written.	Most of the predictions with respect to sinking or floating of different objects are correct, and reasons for predictions are incorrect or partially correct or not written.	All the predictions with respect to sinking or floating of different objects are correct, and reasons for predictions are correct and complete.
7.	Prediction on temp of hot water and cold water.	Predicted temperature of hot water and cold water was much higher or lower than correct temperature.	Predicted temperature of hot water or cold water or both slightly higher or lower than accurate temperature.	Predicted temperature of hot water or cold water or both very nearer to accurate temperature.	Predicted temperature of hot water or cold water or both almost correct and accurate temp.
8.	Prediction on fast dissolving substances in water (crystal sugar or crystal salt or jaggery).	Prediction is incorrect and reason for prediction was incorrect or not written any reasons.	Prediction is correct and written reasons are incorrect or not written any reason.	Prediction is correct and reason for prediction was partially correct and complete.	Predicted correctly and written reasons for prediction was also correct and complete.

9.	Prediction on miscibility and immiscibility of liquids such as coconut oil, kerosene, petrol and honey in water.	None of the predictions are correct and written reasons for prediction are incorrect or not written any reasons.	Few predictions are correct but reasons are incorrect or not written reasons. But most of the predictions and reasons are incorrect.	Most of the predictions are correct and written reasons are correct or partially correct. But few predictions and reasons are incorrect.	All the predictions are correct and written reasons are correct or partially correct.
10.	Prediction on osmosis (thistle funnel experiment).	Prediction is incorrect and reason for prediction was incorrect or not written any reason.	Prediction is correct and the given reason was incorrect or not written any reason.	Predicted correctly and written reason was partially correct.	Predicted correctly and given reason for prediction was correct.
11.	Predict: seed germination faster in soil + fertilizer or soil + manure.	Prediction is incorrect and written reason was incorrect or not written any reasons.	Predicted correctly and written incorrect reasons or not written any reason.	Predicted correctly and reasons for prediction was partially correct.	Predicted correctly and reason for prediction also correct and proper.
12.	Predict: melting of ice faster in which places/ substances.(cold water, Dark place, Salt solution, Sugar solution).	Predicted incorrectly and given incorrect reasons or not written any reason.	Predicted correctly but given reasons are incorrect or not written any reason.	Predicted correctly and given reason is partially correct.	Predicted correctly and given correct and appropriate reason.
13.	Predict: Decreasing of temperature faster in which vessel (aluminium, brass etc).	Predicted incorrectly and written reason is incorrect or not written any reason for prediction.	Predicted correctly and written incorrect reason or not written any reasons for prediction.	Predicted correctly and written partially correct reasons for prediction.	Predicted correctly and written correct reasons for prediction.

14.	Predict: evaporation faster in petrol or water.	Prediction is incorrect and written incorrect reason or not written reason.	Predicted correctly and written reason was incorrect or not written reason.	Predicted correctly but reason for prediction is partially correct.	Predicted correctly and written correct reason for prediction.
15.	Predict about rain	Prediction is incorrect and written incorrect reason or not written reason.	Prediction is correct but written reason was incorrect or not written reason.	Predicted correctly and reason for prediction was partially correct.	Predicted correctly with correct and appropriate reasons.
16.	Predict about a leaf with worm.	None of the predictions are correct, or not written any prediction	Few predictions are correct and most of the predictions are incorrect.	Most of the predictions are correct and few predictions are incorrect.	Student made more number of Predictions correctly based on the observation.

APPENDIX_2.6

RUBRIC FOR INFERENCE SKILL

Name of the Student: **Medium:** English

Standard: VIII **School:** GHSS, Gudalur

Item. No	Parameters of Inference Skill	Beginning Stage	Developing Stage	Accomplished Stage	Proficient Stage
1	Inference based on observation of melting of ice cubes in thistle funnel with thermometer.	Written merely few observations but inference was irrelevant and incorrect.	Somewhat inference is relevant and correct but not complete.	Inference(s) is/are almost correct and relevant but incomplete	Derived inference(s) is/are correct and relevant based on observations.
2	Inference on photosynthesis.	Written just observations about plant picture, not written any inference correctly.	Somewhat inference is relevant, correct , but incomplete.	Inference is almost correct and relevant, but incomplete.	Inferred correctly, completely and clearly based on observations.
3	Inference on Soluble and insoluble substances in water.	Written only observations but inference was not derived or incorrect derived.	Somewhat inference is relevant and correct, but not completely correct.	Written inference is almost correct, but not completely correct.	Inference derived was correctly and completely based on observations.
4	Inference based on acid and base test.	Written all observations correctly but written inference is incorrect and irrelevant.	To some extent inference was relevant and correct, but not complete.	Inference was almost relevant and correct but incomplete inference(s).	Inferred correctly, completely and clearly based on observation of acid base test.
5	Inference on transfer of heat in solid (Experimentation in iron rod)	Written observations are correct but not derived any inference correctly.	To some extent inference was relevant and correct, but not complete.	Inference was almost relevant and correct but incomplete inference.	Derived inference was correct and complete based on observations.

6	(a) Inference on solar eclipse and (b) Inference on lunar eclipse	Written just position of sun, earth and moon by looking the picture but written inference was irrelevant, incorrect or not written any inference.	To some extent written inference is relevant, clear and correct but not completely derived inference.	Written inference is almost correct and relevant but incomplete.	Inferred correctly, completely based on observations.
7	Inference on transpiration	Written observations are correct but inference is irrelevant and incorrect.	To some extent inference is relevant, correct but not complete	Inference is almost relevant, correct but incomplete.	Written inference is correct, complete and clear based on observations.
8	Inference based on floatation of different liquids such as kerosene, castor oil, diesel and honey in water.	Written merely observations but inference was irrelevant, incorrect.	Inference was somewhat relevant and correct but not complete.	Inference was almost correct and clear but incomplete.	Inference made correctly completely and clearly based on observations.
9	Inference based on experiment on absorption of heat by empty inflated balloon, &absorption of heat by inflated balloon with water when brought over the lighted candle.	Observations made correctly but inference derived incorrectly, unclearly and irrelevantly.	To some extent inference was relevant correct, but complete.	Almost written inference was correct and clear, but incomplete.	Written inference was correct, clear and complete based on observations.
10	Inference based on time period for oscillations in different lengths (Simple pendulum experiment).	Observation written correctly but inference was incorrect and irrelevant.	Inference is somewhat relevant and correct, but incomplete.	Inference was almost correct, relevant and clear, but incomplete.	Based on observations student Inferred correctly, completely and clearly.
11	Inference based on observations of water droplets outside the steel tumbler with ice cubes inside.	Written observations are correct but inference was incorrect and irrelevant.	To some extent inference was correct, clear and relevant.	Inference is almost correct, clear and complete.	Inference is correct, complete and clear based on observations.
12	Inference based on observation of experiment on neutralisation of acid base test.	Observations written correctly but Inference was incorrect, unclear and irrelevant.	Somewhat inference was correct, clear and relevant. But not complete.	Inference was almost correct and clear, but incomplete.	Inference was correct, clear and complete based on observations.

13	Inference on change of states of matter experiment (Melting, Sublimation and Vaporisation)	Observations are correct but Inference is incorrect, unclear and irrelevant.	To some extent inference was correct relevant but not complete.	Inference was almost correct, clear and complete.	Written inference was correct, clear and complete based on observations.
14	Inference on anomalous expansion of water in pond	Written some observations from by seeing the picture but inference was incorrect, unclear and irrelevant.	To some extent inference was correct, clear, and relevant.	Inference is almost correct, and clear, but not complete.	Inference is correct, complete and clear based on observations.
15	Inference on food Chain	Written observations are correct but inference was incorrect, unclear and irrelevant.	To some extent Inference was correct, and relevant but incomplete inference.	Inference is almost correct, clear and relevant.	Inference is correct, clear and relevant based on observations.
16	Inference on different types of levers	Written observations are correct but inference was incorrect, unclear and irrelevant.	To some extent Inference was correct, and relevant but incomplete.	Inference is almost correct, clear and relevant.	Inference is correct, clear and relevant based on observations.

APPENDIX_3.1

Close Ended Questionnaire for Basic Science Process Skills

Name of the Student : **Std: VIII**
School : **Time: 30 Min**

Choose the correct answer

Q.1) when we make statement based on observations or experience about what will happen in future.

A. Observation **B.** Defining operationally
C. Communication **D.** Predicting

Q.2) when we make a representation of an object or an idea by verbal or non-verbal.

A. Making models **B.** Predicting
C. Classifying **D.** Communicating

Q.3) when we employ one or more of our 5 senses to collect informations about an object or an event or things called.

A. Communicating **B.** Inferring
C. Observing **D.** Classifying

Q.4) when we quantify the things or liquids using standardized units.

A. Investigating **B.** Measuring
C. Predicting **D.** Calculating

Q.5) when we create definitions or conclusions based on thorough observations.

A. Making models **B.** Inferring
C. Classifying **D.** Observing

Q.6) When we sorting the things/objects based on the common characteristics or certain similar features

A. Communicating **B.** Measuring
C. Classifying **D.** Defining operationally

Q.7) when we convey information through charts, graphs, tables and lab reports

A. Measurement **B.** Making models
C. Communication **D.** Classifying

Q.8) when we test a prediction by doing experiment and collected data and results shared to others

A. Communicating **B.** Measurement
C. Observing **D.** Investigating

Q.9) when we use the following devices such as vernier caliber and screw guage to find out the radius and diameter of marbles and a thread.

A. Measurement | **B.** Formula
C. Calculation | **D.** Inference

Q.10) While doing simple pendulum experiment the following skill(s) will be employed

A. Observation and classification
B. Measurement
C. Communication and observation
D. Observation, measurement, communication and inference

Q.11) if we guess based on observation what will happen next

A. Measurement | **B.** Inferring
C. Predicting | **D.** Observing

Q.12) Determining the length, width, area, volume, weight, mass, volume or temperatures to quantify objects or liquids

A. Observing | **B.** Measuring
C. Communicating | **D.** Inferring

Q.13) Placing the objects or things or substances into different groups/category based on some common characteristics or attributes.

A. Observing | **B.** Classifying
C. Inferring | **D.** Measuring

Q.14) Describe about an object or event or observations to another person

A. Controlling variables | **B.** Presenting data
C. Communicating | **D.** Inferring

Q.15) Deriving a conclusion about an object or event after observations

A. Inferring | **B**. Experimenting
C. Observing | **D.** Communicating

Q.16) When we noticing or identifying the differences between similar objects or pictures

A. Inference | **B**. Experimenting
C. Communication | **D**. Observation

Q.17) When we identifying the similarities between the different objects or events or pictures

A. Inference | **B**. Measurement
C. Observation | **D**. Communication

Q.18) When we noticing the keen details through senses that are very relevant to an investigation or experimentation called

A. Observation | **B**. Defining Operationally
C. Inference | **D**. Classification

Q. 19) When we examine the events or objects or specimens using the magnifying lens called

A. Notification | **B.** Observation
C. Monitoring | **D.** Inference

Q.20) We employ our tongue or nose to identify the taste and smell called

A. Inference | **B.** Observation
C. Communication | **D.** Inference

Q.21) When we use speech or written our ideas and observation or linking one ideas with other

A. Communication | **B.** Classification
C. Inference | **D.** Speaking

Q.22) When we hear/listen to others ideas/ opinions and responding to them.

A. Inference | **B.** Speaking
C. Communication | **D.** Observation

Q.23) When we take notes about an event or an experiment while others doing science demonstration or while watching television or computer called.

A. Experimentation | **B.** Demonstration
C. Listening | **D.** Communication

Q. 24) When we use various science models or specimens or apparatus and explain to others

A. Communication | **B.** Classification
C. Simulation | **D.** Inference

Q.25) When we use graphs, symbols, flowchart, pie diagrams, tables and bar diagram in science to display the data.

A. Measurement | **B.** Communication
C. Inference | **D.** Classification

Q.26) We use appropriate standard units in making comparisons or for taking reading is

A. Observing | **B.** Measurement
C. Observation | **D.** Prediction

Q.27) We use suitable instrument or device for finding/checking the accuracy of diameter or radius.

A. Observation | **B.** Comparisons
C. Measurement | **D.** Calculations

Q.28) When we make a forecast about what will happen in the future based on observation or prior knowledge gained through experience or collected data is

A. Assumptions | **B.** Prediction
C. Conclusions | **D.** Classification

Q.29) We make our keen observations quantitatively by using conventional standard units

B. Calculation | **A.** Measurement
C. Prediction | **D.** Computation

Q.30) When we use thermometer to find out the temperature of water or temperature of room or laboratory is

A. Prediction | **B.** Calculations
C. Measurement | **D.** Inference

Q.31) When we use graduated cylinder for what?

A. Measuring | **B.** Transfer the liquid
C. Reading | **D.** Observing

Q.32) When we use puppets and burette for what?

A. Inferring | **B.** Communicating
C. Measuring | **D.** Computing

Q.33) When we sorting the materials or organisms or objects based some common features or characteristics

A. Communications | **B.** Classification
C. Inference | **D.** Measurement

Q.34) When we grouping or arranging the materials or substances or things based on some common similarities and differences

A. Observation | **B.** Predicting
C. Classification | **D.** Inference

Q.35) When we find out the mass, weight, volume, area, speed, length and breadth is

A. Measurement | **B.** Inference
C. Observations | **D.** Prediction

APPENDIX_4.1

Rating Scale for Basic Science Process Skills

School: GHSS, Gudalur **Medium: English**

Standard: VIII **Time : 60 Minutes**

[Put Tick Mark whichever you feel Correct]

Item No	Statements	Always	Some times	Most of the time	Never
	Observation Skill				
1.	I have observed the important events in science experiment				
2.	I use to observe / notice the similarities and differences of science diagrams				
3.	I have used the magnifying lens during my observations				
4.	I have observed the living insects / leech / earthworm etc in science				
5.	I have used my sensory organs such as nose, ear and tongue during my observations.				
6.	I have observed the smell of some chemicals/ substances in science class				
7.	I have touched some of the chemicals to find out the texture				
8.	I was asked to hear / listen the science experiment audio in the television/ computer				
9.	I have seen the microscope and operated while observing the specimens				
10.	I have observed the slides in the microscope				
11.	I have observed the science experiment/ demonstration performed by the teacher or by other student				
12.	I have observed the various preserved specimens of animals/ insects/ plants kept in the laboratory				
13.	I have observed the science experiment in the multimedia theatre/ projector				
	Classification Skill				
14.	I have classified the objects / materials based on their similarities and differences in science				
15.	I have classified the objects / materials into smaller and bigger based on their size				
16.	I have classified the substances / materials into magnetic and non magnetic				
17.	I have classified the substances or materials into solids, liquids and gases during practical.				

Item No	Statements	Always	Some times	Most of the time	Never
18.	I have classified the substances / chemicals into acids and bases				
19.	I have classified the materials into rough, smooth and plain surfaces				
20.	I have classified materials / substances into conductors of electricity and insulators				
21.	I have classified materials / substances into good conductors of heat and poor conductors of heat				
22.	I have classified the organisms into birds, reptiles, amphibians and insects while observing the organisms in the environment				
23.	I have classified various elements into metals and non metals				
24.	I have classified the materials into transparent , translucent and opaque				
25.	I have classified the organisms into herbivore, carnivores and omnivores				
26.	I have classified the chemical substances into soluble and in soluble				
27.	I have classified the animals into vertebrates and invertebrates				
28.	I have classified the animals into unicellular and multicellular organisms				
29.	I have classified the plants into xerophytes, mesophytes and hydrophytes				
30.	I have seen different types of levers and I classified them into first order, second order and third order levers				
Communication Skill					
31	After completion of science experiment/ demonstration. I have discussed with other students about the same				
32.	When I was discussing with other students, i have used scientific terms				
33.	I asked many questions to teachers during experimentations				
34.	I have presented my observations and inference in the class after the experiments				
35.	I have submitted the written report about the science experiment				
36.	I have drawn the line graph, bar graph and pie chart in science class				
37.	I have prepared the tables, charts and posters in science class				

Item No	Statements	Always	Some times	Most of the time	Never
38.	I use to take notes during the demonstration of experiment				
39.	I have drawn the diagrams and labelled clearly by observing the science models/ charts				
40.	I was asked to read the text book in science class				
41.	I use to write chemical formula while writing the chemical equation				
42.	I use to draw simple flow chart in science				
43.	I was engaged in group discussion in science				
44.	Food chain, food web and energy flow, I have represented by picture/ diagrams				
45.	I have measured the length/ breadth and width of the object				
Measurement Skill					
46.	I have measured the thickness of wire or diameter of wire using the screw gauge				
47.	I have measured the temperature of hot water or cold water using the thermometer				
48.	I have measured the length of the pendulum				
49.	In simple pendulum experiment, I have counted the time taken for 20 (Different numbers of)oscillations in different lengths				
50.	I have used the pointer balance / spring balance to weigh the object				
51.	I have used the measuring cylinder to measure the exact quantity of water or chemical solutions				
52.	I have used the pipette and burette to measure the exact quantity of water or chemical solutions				
53.	I have measured the volumes of irregular objects using the displacement method of water				
54.	I have measured the total area of irregular leaf/ objects using the graph sheet				
Prediction Skill					
55.	I have predicted what will happen in future during the science demonstration/ experiment				
56.	I have predicted the forecasting events when other students performing the experiments				
57.	Before performing the experiment, I have made predictions about the future event.				

Item No	Statements	Always	Some times	Most of the time	Never
Inference Skill					
58.	I have written my own inference based on the several observations of experiment				
59.	I have discussed with friends about the experiment and derived inference by own				
60.	My teacher demonstrated the science experiment but inference I have written by own				

APPENDIX_5.1

Semi Structured Interview for Students of Standard VIII (before Intervention Programme)

The following semi structured questions were asked during focus group interview with students before implementation of intervention programme and further probed to draw out more information.

- What are Science Process Skills?
- Did your science teacher teach about science process skills earlier?
- Did you visit laboratory, and have you ever engaged in doing experiments by your own either in the laboratory or classroom?
- Did you ever operate microscope for observing the specimens?
- Did you use magnifying lens for observing the fine details which are not able to see through our eyes?
- Have you done simple pendulum experiments by your own?
- Have you touched, smelled, observed the chemicals?
- Did you measure water or liquids with the help of pipette or burette in the science class?
- Did you observe plant and animal specimens in laboratory?
- Whether your science teacher demonstrated any experiments to enhance Process Skills?
- What was the teaching method followed by the teacher in earlier classes?
- Did you classify the things, objects, materials, substances based on similarities and differences?
- Have you plotted graph, bar diagram, tables, pie chart for the given data; or do you know the symbols for chemical elements, symbol for electrical components?
- Have you measured the length, breadth, height, temperature using appropriate devices?
- Have you made any attempt to write inference by your own?

APPENDIX_5.2

Semi Structured Interview for Students of Standard VIII (after Intervention Programme)

The following semi structured questions were asked during focus group interview with students after implementation of intervention programme and further probed to draw out more information.

- What are the types of science process skills?
- Which are the Process Skills you acquired through Intervention Programme?
- How did you learn science during the period of intervention programme?
- Does all the experiments and activities included in the programme was appropriate to your cognitive abilities?
- Did you like experiential learning method of teaching?
- Which are the sensory organs you employed while observation?
- Can you able to measure length, breadth, height, weight, temperature using suitable instrument?
- Can you able to classify the objects, things, substances based on similarities and differences?
- Can you able to draw table, graph, and pie chart if data is given?
- How will you predict about the forecasting events or occurrences?
- Can you able to derive inference based on observations of experiments, pictures?

APPENDIX_5.3

Semi Structured Interview for non-sampled Students (after Intervention Programme)

The following questions were asked to students who were not sample for the present study (VIII standard Tamil medium). The questions were asked after completion of intervention programme to know about their status of process skills.

- Do you know about science Process Skills?
- Have you ever studied Science Process Skills and its types?
- Did you operate microscope and simple pendulum?
- Did you use hand lens for observation?
- Have you seen thermometer and burette?
- Did you measure length, breadth, height, and temperature, mass during the science class?
- Do you know to classify the things according to similarities and differences?
- Can you draw tables, graph, and pie chart in science?
- How will you predict about the future events or occurrences?
- Can you able to write inferences based on observations?

APPENDIX_5.4

Semi Structured Interview for Parents and Siblings ((after Intervention Programme)

Following semi structured interview questions were asked with parents after intervention programme and further probed.

- Did your child discuss about how was the science teaching in standard eight?
- Did your child discussed about hands on experiences and role play in science?
- What method of teaching learning you would like to suggest teachers to teach science?
  - Lecture method or hands on experience method?
- Did your child discuss about laboratory visit and hands on experiences in science?
- Did your child discuss about method of science teaching? And did your child share about handling science apparatus such as simple pendulum hand lens and chemicals etc?
- Did your child discuss about how do they observe, classify, measure etc?

APPENDIX_6.1

List of experts Validated the Tools and Intervention Programme

Prof. Manjula P. Rao Regional Institute of Education Mysore, NCERT Manju882002@yahoo.com.	Prof. V.D Bhatt Regional Institute of Education Mysore NCERT Karnataka. bhatvd@yahoo.com
Prof. Lakshminarayan Regional Institute of Education Mysore, NCERT undurthy@gmail.com	Prof. S Kumar (Rtd) Department of Education, CASE Faculty of Education and Psychology The M S University of Baroda Vadodara
Prof. R.G. Kothari Department of Education, CASE Faculty of Education and Psychology The M S University of Baroda Vadodara. rgkothari@yahoo.com.	Prof. R.S. Mani Department of Education, CASE Faculty of Education and Psychology The M S University of Baroda Vadodara
Prof. D. R. Goel (Rtd) Department of Education, CASE Faculty of Education and Psychology The M S University of Baroda Vadodara. Goel_d_34@rediffmail.com	Prof. Ashutosh Biswal Department of Education, CASE Faculty of Education and Psychology The M S University of Baroda Vadodara
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Dr, Shashi Vanzari Head, Dept of Education Nagpur University	Prof. Bharat Joshi Department of Education Gujarat Vidyapeeth, Ahmadabad

APPENDIX_ 7.1

PERMISSION LETTER FOR DATA COLLECTION

From:
Ramesh M
UGC Research Scholar,
Centre of Advanced Study in Education,
Faculty of Education and Psychology,
The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat
Date: 6. 5. 11

Through Proper Channel

To,
The Chief Educational Officer,
Nilgiri district,
Udhagamandalam, Tamilnadu.

Subject: Permission for data collection

Respected Sir,
Greetings!
I am doing Ph.D. on ***"Acquisition of Science Process skills through Experiential Learning among Students of Standard VIII"*** under the guidance of Dr. R. C. Patel, Reader in Education, (CASE), Faculty of Education and Psychology, The M S University of Baroda, Vadodara. As a part of my study, I need to collect the data from one of the schools following Tamilnadu State Board Syllabus. Based on all practical aspects like; facilities available, expected cooperation and nearness of school from my residence, I would like to undertake my study in Gudalur Government Higher Secondary School, Gudalur Taluka of Nilgiri district. I assure you that I will be handling science subject among the students of standard VIII for almost one full academic year (2011-2012) and shall fulfill all the requirements of completing syllabus, helping in assessment of students and other normal duties in the school.

In this connection, may I request your kind self to grant me the permission to carry out my Ph. D. work in the above stated school?

With Kind Regards!
Thanking you in anticipation of positive response.

Yours faithfully,
6. 5. 11
Ramesh M

CENTRE FOR ADVANCED STUDY IN EDUCATION
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA
VADODARA

Dr. R. C. Patel
Guide
Reader in Education
Centre of Advanced Study in Education
Faculty of Education & Psychology
The M. S. University of Baroda
Vadodara

Prof. S. C. Panigrahi
Head, CASE
Centre of Advanced Study in Education
Department of Education
Faculty of Education & Psychology

Prof. D. R. Goel
Dean
DEAN
FACULTY OF EDUCATION & PSYCHOLOGY
M. S. UNIVERSITY OF BARODA
VADODARA

Copy to
1. **The DEO, Gudalur Taluka, Nilgiri district, Tamilnadu**
2. **The Head Master, Gudalur Higher Secondary School, Gudalur, Nilgiris.**

APPENDIX_ 7.2

CERTIFICATE FROM SCHOOL HEAD MASTER

From

The Head master
Govt Hr Sec School
Gudalur

To

Whom soever it may concerned

Respected sir

This is to certify that Ramesh M, Ph D student of Dr R.C Patel, reader in Education, Faculty of Education and Psychology (CASE) The Maharaja Sayajirao University of Baroda, Gujarat. As a researcher he experimented the strategy (Experiential learning) in students of standard VIII throughout the academic year of 2011 – 2012 for developing Science process skills. During the period of experimentation, researcher sincerely followed the school regularity and timings, he stayed full school hours for implementing the strategy and engaging the students in science experiments, I also came to know from students and teachers that the students acquired process skills through this method of teaching (Experiential learning).

Thanking you

By

9-4.12

Place: Gudalur, The Nilgiris

Date: April 2012

HEAD MASTER
Govt. Hr Sec School

APPENDIX_ 8.1

COURSEWORK CERTIFICATE

सत्यं शिवं सुन्दरम्

THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

CERTIFICATE

[As per O.Ph.D. 2 under UGC (Minimum Standards and Procedure for Awards of M.Phil./Ph.D. Degree) Regulation, 2009 for 15 Credits to be earned by Ph.D. Scholars]

This is to certify that **Mr.Ramesh M,** Research Scholar, registered under UGC (*Minimum Standards and Procedure for Awards of M.Phil./Ph.D. Degree) Regulation, 2009,* vide Registration Certificate Number **484** dated **12/3/2010**, for pursuing Ph.D. on has undertaken and completed the course work with the **Grade A.**

STATEMENT OF CREDITS EARNED

Name of Research Scholar: **Mr. Ramesh M** *(M)*

Faculty/Institution: Faculty of Education & Psychology

Department: Education

Paper Number	Course Title	Course Credits	Grade Earned
Core Courses – 09 Credits *[Offered At University Level]*			
I.	Introduction to Research & Research Writings	3	B
II.	Introduction to Basic Computer Functions & Application for Research Purposes	3	B
III.	Quantitative Research Techniques & Data Analysis	3	B
Departmental Courses – 06 Credits *[Offered at Departmental Level]*			
IV.	Review of Related Literature	3	A
V.	Conceptual Framework	3	A
		Overall Grade	**A**

ACA3/5

Date of Issue: 02/05/2013

Place: Vadodara

Registrar (OSD)

Grade Conversion Table and Grade Calculation Formula

Grade	Grade Points	Range
O	10	Above 9.01
A	9	8.01 – 9.00
B	8	7.01 – 8.00
C	7	6.01 – 7.00
D	6	5.01 – 6.00
E	5	4.01 – 5.00
F	4	Below 4.00

$$Overall\ Grade = \frac{\sum(Grade\ Points \times Credits)}{\sum Credits}$$

APPENDIX_9.1

Gudalur Government Higher Secondary School, Gudalur The Nilgiris