Chapter - 3
Chapter - III

PLAN AND PROCEDURE

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3.7.4 Daywise activities were carried out is given as below:
Research purifies human life. It improves its quality. It is a search for knowledge. It shows how to solve any problem scientifically. It is a careful enquiry through search for any kind of knowledge. It is a journey from known to unknown. It is a systematic effort to gain new knowledge in any kind of discipline. When it seeks a solution of any educational problem, it leads to educational research. Curiosity, inquisitiveness is natural gifts secured by a man. They inspire him to quest, increase his thirst for knowledge and truth. After trial and error, he worked systematically in the direction of the desired goal. His adjustment and coping with situation makes him successful in his task. Thereby he learns something’s, becomes wise and prepares his own scientific procedure while performing the same task for second time. So is there any relationship among science, education and educational Research?

Research is the voyage of discovery. It is the quest for answers to unsolved problems.

Research is required in any field to come up with new theories or modify, accept, or nullify the existing theory. From time immemorial it has been seen so many discoveries and inventions took place through research and world has got so many new theories, which help the human being to solve his problems. Graham Bell, Thomas Edison, J.C. Bose, John Dewey, Skinner, Piaget, researcher like these have given us theories which may cause educational progress research needs expertise.

3.1 Meaning of Educational Research

Educational Research as nothing but cleansing of educational Research is nothing but cleansing of educational process. Many experts think Educational Research as under-

According to Mouly, — Educational Research is the systematic application of scientific method for solving for solving educational problem.

Travers thinks, — Educational Research is the activity for developing science of behavior in educational situations. It allows the educator to achieve his goals effectively.

According to Whitney, — Educational Research aims at finding out solution of educational problems by using scientific philosophical method.

Thus, Educational Research is to solve educational problem in systematic and scientific manner, it is to understand, explain, predict and control human behavior.
Educational Research Characterizes as follows:

1. It is highly purposeful.
2. It deals with educational problems regarding students and teachers as well.
3. It is precise, objective, scientific and systematic process of investigation.
4. It attempts to organize data quantitatively and qualitatively to arrive at statistical inferences.
5. It discovers new facts in new perspective. i.e. It generates new knowledge.
6. It is based on some philosophic theory.
7. It depends on the researchers ability, ingenuity and experience for its interpretation and conclusions.
8. It needs interdisciplinary approach for solving educational problem.
9. It demands subjective interpretation and deductive reasoning in some cases.
10. It uses classrooms, schools, colleges department of education as the laboratory for conducting researches.

3.1.2 Research Methodology

The term methodology seems to be broader, in the sense it includes nature of population, selection of sample, selection / preparation of tools, collection of data and how data will be analysed. Here the method of research is also included. It is simply the method for conducting research.

Generally, such methods are divided into quantitative and qualitative methods. Such quantitative methods include descriptive research, evaluation research and assessment research. Assessment type of studies include surveys, public opinion polls, assessment of educational achievement. Evaluation studies include school surveys, follow up studies. Descriptive research studies are concerned with analysis of the relationships between non-manipulated variables. Apart from these quantitative methods, educational research also includes experimental and quasi-experimented research, survey research and causal-comparative research.

Qualitative research methods include ethnography, phenomenology, ethno methodology, narrative research, grounded theory, symbolic interaction and case study. Thus, the researcher should mention about methods of research used in his research with proper justification for its use.
Educational research methods are classified in following three types

1. **Historical research**
   In historical research, the investigator studies documents and other sources that contain facts concerning the research theme with the objective of achieving better understanding of present policies, practices, problems and institutions. An attempt is made to examine past events or combinations of events and establish facts in order to arrive at conclusions concerning past events or predict future events.

2. **Descriptive Research Method**
   The descriptive research attempts to describe, explain and interpret conditions of the present. The purpose of a descriptive research is to examine a phenomenon that is occurring at a specific place(s) and time. A descriptive research is concerned with conditions, practices, structures, differences or relationships that exist, opinions held, processes that are going on or trends that are evident.

3. **Experimental Research Method**
   The experimental method in educational research is the application and adaptation of the classical method of experimentation. It is a scientifically sophisticated method. It provides a method of investigation to derive basic relationships among phenomena under controlled condition or, more simply, to identify the conditions underlying the occurrence of a given phenomenon. Experimental research is the description and analysis of what will be, or what will occur, under carefully controlled conditions.

   Experimental research provides a method of Hypotheses testing. Hypothesis is the heart of experimental research. After the experimenter defines a problem, they propose a tentative answer to the problem or hypothesis. Further, they test the hypothesis and confirm or disconfirm it. Although, the experimental method has greatest utility in the laboratory, it has been effectively applied non-laboratory settings such as the classroom, where significant factors or variables can be controlled to some degree. The immediate purpose of experimentation is to predict events in the experimental setting. The ultimate purpose is to generalize the variable relationships so that they may be applied outside the laboratory to a wider population of interest.

**3.2 Research Design**

Research design is a blue print or structure with in which research is conducted. It constitutes the blue print for the collection, measurement and analysis of data. According to Gay and Airasian (2000), — A design is general strategy for conducting a research study. The nature of the hypothesis, the variables involved, and the constraints of the —real world all contribute to the selection of design.
The research design is an outline of what the researcher will do from writing of objectives, hypotheses and its operational implications to find analysis of data. A research design helps the investigator to obtain answers to research problem and issues involved in the research, since it is the outline of entire research process.

1) Design also tells us about how to collect data, what observation are to be carry out, how to make them, how to analyze the data.

2) Design also guides investigator about statistical techniques to be used for analysis.

3) Design also guides to control certain variables in experimental research.

Thus, design guides the researcher to carry out research step by step in an efficient way. The design section is said to be complete/adequate if researcher could carry out his research by following the steps described in design.

3.3 Nature of Problem and Approach of the Present Study

The nature of problem and its context is discussed in previous chapter (Chapter - I) but here the discussion is initiated with methodological point of view. Present problem was related with development of specific teaching strategies to enhance levels of scientific literacy and scientific process skills and to determine its effect. As the main focus is related to find out the cause and effect relationship. So the researcher has selected experimental method.

3.4 The Experimental Method

The experimental researches in educational or social sciences are not exactly likely to natural sciences but it deals with the characteristics as given below –

1. Control
2. Manipulation
3. Observation
4. Replication

The issues related to selection, control, manipulation of variables and design of the functioning is described here.

3.4.1 Variables in Research

Control and manipulation of the variables is the basic idea of experimental research. Due to this control and manipulability, one can establish the casual relationship between variables. These variables are majorly categorized as independent and dependent variables.
The variable involved in present study are as follows:

3.4.1.1 Independent Variable

An experiment is conducted to examine the effect of a variable or treatment, which is known as Independent variable. The main attention is given in the experiment to observe its effect. Independent variables are inputs. They are manipulated to determine the relationship and they can affect the other variables. There are two types of independent variables i) Treatment independent variables ii) Attribute independent variables.

For this study, teaching strategies is treatment independent variable. Gender and faculty of student teachers is attribute variables.

3.4.1.2 Dependent Variables

The basis on which the effectiveness of the experimental variable is established or studied is known as the dependent variable. Dependent variables are products of independent variables. They are the resulted due to cause of independent variable.

Here, present study measures scientific literacy level and scientific process skills among student teacher as a result of implementation of teaching strategies.

The variables involved in this study are shown in following table

Table No. 3.1

<table>
<thead>
<tr>
<th>Particulars of the Variables Involved in Present Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sr. No.</td>
</tr>
<tr>
<td>--------</td>
</tr>
</tbody>
</table>
| 1      | i) Treatment Independent Variable.  
     | ii) Attribute independent variable. | Teaching Strategies  
     |                                           | Gender, faculty of student teacher |
| 2      | Dependent Variables | Scientific Literacy Level, Scientific Process Skills |

In experiment, there are some extraneous variables other than independent and dependent variables.

3.4.1.3 Control of Extraneous Variables

In experiment, a number of extraneous variables are present. These variables can influenced on result of experiments. Although these extraneous variables usually cannot be completely eliminated, many of them can be identified. Hence, researcher anticipate them and take all possible precautions to minimize their influence through sound experiment design and execution, in following manner.

1. **Maturation**: This threat is controlled by randomly assigning subject to experimental and control groups. Difference between the groups were then considered to be due to the treatment rather than to maturation.
2. **History**: Researcher selected pre test – post test equivalent group design, hence, external events have a similar effect on both experimental and control group and this threat was controlled.

3. **Testing**: Pre testing may produce a practice effect making subjects more proficient in subsequent test performance, but control group is present. Hence, difference between the groups were considered to be due to treatment rather than practice effect of testing.

4. **Statistical Regression**: For the control of statistical regression the researcher randomly assign his sample (high, medium and poor) in experimental and control groups.

5. **Selection Bias**: To control this variable researcher randomly assigned subjects in experimental and control group. Due to randomization, there is no chance of selection bias.

6. **Experimental Mortality**: Present research was a long term experiment. Hence, there is chance of mortality or toss of subject. by this consideration researcher selected more subjects. For the purpose of experiment there were 35 students in control and 45 students in experimental group, but by considering loss of subject (by record) researcher select 33 students in control group and 43 in experimental group, for the purpose of statistical calculation.

Control of variables also include the issue of validity as experiment. The validity of experiment is mentioned by removal of threats to validity and selection of experimental design.

### 3.4.2 Experimental Designs

There are various types of experimental designs. The selection of a particular design depends upon factors like nature and purpose of experiment, the type of variables to be manipulated, the nature of the data, the facilities available for carrying out the experiment and the competence of the experimenter.

The following categories of experimental research designs are popular in educational research:

- **i. Pre-experimental designs** – They are least effective and provide little or no control of extraneous variables.

- **ii. True experimental designs** – employ randomization to control the effects of variables such as history, maturation, testing, statistical regression, and mortality.

- **iii. Quasi-experimental designs** – provide less satisfactory degree of control and are used only when randomization is not feasible.

- **iv. Factorial designs** - more than one independent variables can be manipulated simultaneously. Both independent and interaction effects of two or more than two factors can be studied with the help of this factorial design.
### 3.4.2.2 Experimental Design for Present Study

Experimental research design for present study is the Non-Equivalent Groups Design.

<table>
<thead>
<tr>
<th>Pre-test</th>
<th>Independent Variable</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yb</td>
<td>X</td>
<td>Ya (Experimental)</td>
</tr>
<tr>
<td>Yb</td>
<td>-</td>
<td>Ya (Control)</td>
</tr>
</tbody>
</table>

- **E** – Experimental group
- **C** – Control group
- **X** – Independent variable
- **Y** – Dependent variable
- **Yb** – Dependent variable measures taken before experiment/treatment (Pre-test)
- **Ya** – Dependent variable measures taken after experiment/treatment (Post-test)

(Dhoeny, D.S. (1988))

Pretests are administered before the application of the experimental and control treatments and posttests at the end of the treatment period. Pretests scores can be used in analysis of covariance to statistically control for any differences between the groups at the beginning of the study. There may be a possibility of the influence of the interaction effect of testing with the experimental variable.

### 3.5 Sampling

The researcher is concerned with the generalize ability of the data beyond the sample. For studying any problem, it is impossible to study the entire population. It is therefore convenient to pick out a sample out of the universe proposed to be covered by the study. The process of sampling makes it possible to draw valid inferences or generalizations on the basis of careful observation of variables within a small proportion of the population.

#### 3.5.1 Need for Sampling

- Large population can be conveniently covered.
- Time, money and energy is saved.
- Helpful when units of area are homogenous.
- Used when percent accuracy is not acquired.
- Used when the data is unlimited.

#### 3.5.2 Characteristics of a Good Sample

A good sample should possess the following characteristics:

- A true representative of the population
• Free from error due to bias
• Adequate in size for being reliable
• Units of sample should be independent and relevant
• Units of sample should be complete precise and up to date
• Free from random sampling error
• Avoiding substituting the original sample for convenience

3.5.3 Techniques of Sampling

There are different types of sampling techniques based on two factors viz. (1) the representation basis and (2) the element selection technique on the representation basis. The sample may be probability sampling or it may be non-probability sampling. On the element basis, the sample may be either unrestricted or restricted. Here we will discuss about two types of sampling viz.

(a) Probability Sampling

A probability sample is one in which each member of the population has an equal chance of being selected. Following are techniques of probability sampling

1. Simple random sampling
2. Systematic sampling
3. Stratified sampling
4. Cluster sampling
5. Multi stage sampling

(b) Non-Probability Sampling

A non-probability sample is one in which a particular member of the population being chosen is unknown. The following are techniques of non-probability sampling

1. Purposive Sampling
2. Convenience Sampling
3. Quota Sampling
4. Snowball Sampling

Experimental approach of study requires sample for the purpose of particular treatment. There are many ways to select the samples and to arrange their groups. But this selection and grouping is aimed to construct controlled, system, environment that allows to manipulate predetermined variable only. Except the independent variable, all variables are restricted to interfere in the situation. So one can establish the relation between independent and dependent variables.
The selection of samples for experiment involves –

1. Identification of attributes of sample
2. Techniques for selection
3. Size of sample

3.5.4 Identification of Attributes of Samples

The present study requires representative individuals from the strata of student teachers in Marathi medium. The attributes of the samples are given below.

3.5.4.1 Student Teachers

The students studying D. T. Ed. Course in Marathi medium are selected as student teachers. The study is restricted to science content of upper elementary level. Therefore second year student teachers are selected.

3.5.5 Techniques for Selection

The sample is selected by following technique. Researcher has selected two D. T. Ed. College as per his convenience. Population and Sampling Flow Chart of Student Teacher is as follows:
Table No. 3.2
The Summary of Purpose and Technique Applied in Selection of Sample of D. T. Ed. Student Teacher

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Purpose</th>
<th>Technique of Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D. I. T. Ed, Kolhapur</td>
<td>To prepared experimental group</td>
<td>Convenient method</td>
</tr>
<tr>
<td>2</td>
<td>Shri Chh. Shahu Jr. College of Education, Rukadi, Kolhapur</td>
<td>To prepared control group</td>
<td>Convenient method</td>
</tr>
</tbody>
</table>

In present study, the sizes of sample in both group are as follows:

3.5.6 Student Teacher
Sample consists of 80 student teachers from two colleges.

Table No. 3.3
Sample Size of Experimental and Control Group of student teachers

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Group</th>
<th>Sample Size for Experimental</th>
<th>Sample Size for Statistical Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Experimental</td>
<td>45</td>
<td>43</td>
</tr>
<tr>
<td>2</td>
<td>Control</td>
<td>35</td>
<td>33</td>
</tr>
<tr>
<td>3</td>
<td>Total</td>
<td>80</td>
<td>76</td>
</tr>
</tbody>
</table>

List of student teachers is attached in appendix.

3.6 Tools for Data Collection
Tools provide the way to collect the data. Research has some criteria and those tools help to get the require data as per the criteria. Tools can have many forms like tests, questioners, interviews etc. The tools should be reliable so that they can provide an appropriate data for research.

3.6.1 Tools for Present Study
a) Scientific aptitude Test for college students (SATCS)
b) Nominal and Functional Scientific Literacy Test (Developed by Researcher)
c) Conceptual Scientific Literacy Test (Developed by Researcher)
d) Multidimensional Scientific Literacy Test (Developed by Researcher)
e) Scientific Process Skill Test (Developed by Researcher)
f) Teaching strategies
g) Check List (Developed by Researcher)
a) Scientific aptitude Test for college students (SATCS) By Dr. A. K. P. Sinha (Patna), Dr. L. N. K. Sinha (Patna)

1. To test scientific aptitude of student teachers researcher used “standard scientific aptitude test for college students” developed by Dr. A. K. P. Sinha and Dr. L. N. K. Sinha.

2. This test consists of seven sections, first four sections and last 7th section has been selected by researcher for implementation because these sections appropriate for D. T. Ed. student teachers.

3. This test is originally in English language. To carry out this test in the colleges selected by researcher. It is necessary to translate this test in to Marathi because language of curriculum of student teachers is Marathi.

4. Questions in test are arranged in following manner-

<table>
<thead>
<tr>
<th>Section</th>
<th>Areas</th>
<th>Types of questions</th>
<th>No. of questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Experimental bent</td>
<td>Multiple choice question</td>
<td>5</td>
</tr>
<tr>
<td>II</td>
<td>Ability to reason</td>
<td>Choose correct or wrong</td>
<td>6</td>
</tr>
<tr>
<td>III</td>
<td>Illogical conclusions</td>
<td>Respond by example</td>
<td>3</td>
</tr>
<tr>
<td>IV</td>
<td>Caution and thoroughness</td>
<td>Multiple choice question based on paragraph</td>
<td>4</td>
</tr>
</tbody>
</table>

Reliability of Test – Test - Retest for sample 58 is found 0.81

Scientific aptitude Test for college students (SATCS) attached in appendix.

b) Nominal and Functional Scientific Literacy Test (Developed by researcher)

1. To test nominal and functional scientific literacy levels of student teachers researcher developed this test. A test found at website belong to Harvard university ,having a separate section named MOSART self service sites. There are various tests available and arranged grade wise. Those tests are available on this web site are developed by the team of researchers in the Science Education Department of the Harvard-Smithsonian Center for Astrophysics. The content of the questions is based on published studies of science misconceptions and the NRC National Science Education Standards. Research scientists in the specific content areas evaluated draft questions for scientific accuracy and the development team iterated revisions with the scientists until all comments were resolved. Researcher analyzed all tests and selected questions according to research objective belong to subjects physics, chemistry and biology.
2. By using selected questions from MOSART self service sites researcher developed tests each for physics, chemistry and biology. Tests consists of multiple choice questions. These selected questions are translated in to Marathi.

3. These multiple-choice tests that can be used to assess misconceptions among students teachers' and understanding of science concepts.

4. Question are selected on the basis of selected science content as following manner.

5. These developed tests were sent for validation to experts for their valuable suggestions regarding to levels of questions, numbers of questions, language of questions and modifications if any.

6. Experts have suggested –
   1) Language should be simple to understand
   2) Answer of each question should have justification

7. some modification related to language ,levels of questions .One of the experts suggested that add justification of answer given by student so that researcher can understand misconception as well as scientific content understanding of student teachers.

8. As per the expert’s suggestion researcher added justification of the answers, which helped to judge level of functional literacy of student teachers.

9. Researcher added all suggestions given by expert and developed test.

10. These tests were used for pilot study following are the observation of pilot study regarding this test.
    i) Students were not able to understand some specific question.
    ii) Researcher presented some example of solving such type of question.
c) Conceptual Scientific Literacy Test (Developed By Researcher)

<table>
<thead>
<tr>
<th>Physics</th>
<th>No. of Questions</th>
<th>Chemistry</th>
<th>No. of Questions</th>
<th>Biology</th>
<th>No. of Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement</td>
<td>1</td>
<td>Classification of matter</td>
<td>2</td>
<td>Living organisms-characteristics and</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>classification, Parts of plant</td>
<td></td>
</tr>
<tr>
<td>Force</td>
<td>2</td>
<td>Atomic structure</td>
<td>3</td>
<td>Organics system-Digestive system,</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nervous system</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Circulation system</td>
<td></td>
</tr>
<tr>
<td>Motion and types of motion (3)</td>
<td>3</td>
<td>Chemical reaction and types of</td>
<td>4</td>
<td>Food and food safety</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>chemical reaction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple machine -</td>
<td>-</td>
<td>Metals and nonmetals</td>
<td>3</td>
<td>Dieses</td>
<td>2</td>
</tr>
<tr>
<td>Work and Energy-Light, Sound,</td>
<td>14</td>
<td>Carbon and compound of carbons</td>
<td>2</td>
<td>Cells and Microorganism.</td>
<td>4</td>
</tr>
<tr>
<td>Magnet, Heat and Electricity(14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Acids and bases</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

1. To find out the conceptual scientific literacy level of student teachers researcher developed unit wise various tests according to Physics, Chemistry & Biology. To prepare questions in tests researcher gone through various educational websites like physicsclassroom.com, sciencekids.co.nz, syvum.com, ducksters.com, indiabix.com, neok12.com.

2. There are several tests available unit wise, grade wise. Researcher selected various questions according to selected science unit, translated them in Marathi and reconstructed questions. Prepared tests for each subject physic, chemistry and biology.

3. These tests are consist of various forms of questions like multiple-choice question, true-false, fill in the blanks, Match the following, short answers, classification of objects. These tests are used to understand scientific knowledge and use of knowledge in daily life of student teachers related to specific unit.

4. As per selected science content researcher prepared tests unit wise for physics chemistry and biology.

5. These prepared tests were sent to experts for suggestion, Experts suggested,
i) Language should be simple to understand
ii) More focus on question arise from day to day life situations

6. These tests were used for pilot study following are the observation of pilot study regarding this test.
   i) Students were not able to understand some specific question.
   ii) Researcher presented some example of solving such type of question.

d) Multidimensional Scientific Literacy Test (Developed By Researcher)

1. This test was prepared to find out multidimensional literacy level among student teachers.

2. To test this level researcher had designed tests, which includes day to day life circumstances. There were five different tasks included, On which multiple questions targeting to each task were asked.

3. To prepare this test researcher used the theory proposed by Bybee for multidimensional scientific literacy in his book - Achieving Scientific Literacy: From Purposes to Practices, Jul 3, 1997) and the research carried by Schwartz - The use of scientific literacy taxonomy for assessing the development of chemical literacy among high-school students in which he evaluated scientific literacy level of students.

4. Student have to go through the sessions carried out earlier by researcher and use their knowledge and skills to answer these questions

5. This test was sent to experts for their suggestions, they have suggested to include more focus on simple daily life circumstances then complex one. Hence these tests were changed entirely and some very simple circumstances were selected for tests.

6. This test was used for pilot study following are the observation of pilot study regarding this test.
   i) Students were not able to understand some specific question.
   ii) Researcher presented some example of solving such type of question.

e) Scientific Process Skill Test (Developed By Researcher)

1. This test was carried out to find scientific process skills among student teachers.
2. In traditional way carried out experiments is the way to test scientific process skills, but researcher shown that scientific process skills can be tested through carried out using test containing open-ended and close-ended questions.

3. Researcher has referred several websites and books to find out questions needed for test. Book on science process skills authored by Angeline Tan and UNESCO sourcebook for science in the primary school were the prime sources of questions for this test.

4. This test converted into language Marathi.

5. This test sent to experts for their valuable suggestion. Expert suggestion were related to formatting of the test and they kept the matter intact.

6. This test was used for pilot study following are the observation of pilot study regarding this test.
   i) Student were not able to understand some specific question.
   ii) Researcher presented some example of solving such type of question. It is observed that student understood the scenario and attempted the test.

A structured way to teach certain topic are often called as teaching strategies, to enhance scientific literacy instead of using traditional strategies, to enhance scientific literacy and scientific process skills purposes specific teaching strategies. To develop this strategies levels of scientific literacy are considered as base. This means to enhance particular scientific literacy level a specific teaching strategies need to be used. Similarly to enhance scientific process skills same or different strategies can be used. Details of these strategies are explained in Chapter No. 4.

f) Check List (Developed By Researcher)

This tool was used by the experts to validate the tools used by researcher as well as the supportive material like enriched textual content, video CD, video clips etc.

3.7 Procedure for Data Collection

3.7.1 Preparatory Phase

a) Selection of Scientific Literacy Components and Scientific Process Skills

1. Researcher has gone through several educational websites, research papers and textual references for selecting literature related to scientific literacy.
2. The selected literature was analyzed and the concepts regarding scientific literacy suitable for this research were selected.

3. Further in this research scientific process skills are equally important hence researcher had referred educational portals, textual literature and research papers to select scientific process skills in relation with concept of scientific literacy.

4. The scientific literacy concept proposed by Rodger W. Bybee was selected to carry out this research.

5. The program “Science-A Process Approach(SAPA)” in which two types of scientific process skills were used i.e. Basic scientific process skills and Integrated process skills, researcher choose only the Basic Scientific Process skills for the research.

b) Selection of Science Content with respect to scientific literacy and scientific process skills

Science textual content was analyzed and selected from the syllabus of upper elementary level with respect to scientific literacy and scientific process skills.

c) Development of teaching strategies for scientific literacy and scientific process skills

1. Analyzed teaching methods and techniques suggested by several researchers for science pedagogy.

2. Selected teaching methods and techniques were discussed with guide and finalized suitable teaching strategies for present study.

d) Preparation of content enriched material

1. The selected science content was not possible to use as it is hence enrichment was done by adding activities and augmented science content to develop supportive material.

2. Preparation of multimedia based material to provide visual experience.

3. Prepared kits for experiments - 1) Electromagnetic set for students 2) Pictorial presentation 3) Preparing models from scrap 4) Prepared multimedia CD 5) Textual content enrichment by adding information in the selected concepts.
e) Preparation of tests and tools

<table>
<thead>
<tr>
<th>Tests and Tools</th>
<th>Medium of Test</th>
<th>Prepared by</th>
<th>No. of Copies used</th>
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</thead>
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<tr>
<td>1) Scientific aptitude Test for college students (SATCS)</td>
<td>English translated in Marathi</td>
<td>Standard Test</td>
<td>80</td>
</tr>
<tr>
<td>2) Nominal and Functional Scientific Literacy Test</td>
<td>Marathi</td>
<td>Prepared by Researcher</td>
<td>80 X 3</td>
</tr>
<tr>
<td>3) Conceptual Scientific Literacy Test</td>
<td>Marathi</td>
<td>Prepared by Researcher</td>
<td>45 X 20</td>
</tr>
<tr>
<td>4) Multidimensional Scientific Literacy Test</td>
<td>Marathi</td>
<td>Prepared by Researcher</td>
<td>45</td>
</tr>
<tr>
<td>5) Scientific Process Skill Test</td>
<td>Marathi</td>
<td>Prepared by Researcher</td>
<td>45 X 3</td>
</tr>
<tr>
<td>6) Check List</td>
<td>Marathi</td>
<td>Prepared by Researcher</td>
<td>15</td>
</tr>
</tbody>
</table>

f) Selection of Experts and Resource Person

Experts are selected from the area of science education mainly from professors of college of education worked in science methods, school teachers and professors of science.

Resource persons are selected according to concepts selected for research. These persons were the experts in their concern area.

List of experts and resource persons is attached in appendix.

3.7.2 Developmental Phase

Step 1 – The selected science content was not possible to use as it is hence enrichment was done by adding activities and augmented science content to develop supportive material.

Step 2 – A multimedia based material is developed to provide elaboration of abstract science concepts.

Step 3 – Developed teaching strategies for the present study. This is discussed in Chapter 4.

3.7.3 Experimentation Phase

For implementing teaching strategies and testing scientific literacy, researcher was made two groups i.e. experimental and control groups. For this implementation two colleges ate different locations were selected. To test the scientific literacy and scientific process skills Physics, Chemistry and Biology subjects were chosen and similar teaching strategies were implemented for each subject.

Step 1 – To check the scientific ability of student teachers, SATCS test was carried out at both colleges.

Step 2 – Implementation of nominal and functional scientific literacy test to find out level of scientific literacy level among student teachers of both groups.
Step 3 – To enhance nominal and functional level researcher implemented selected teaching strategies on experimental group.

Step 4 – To evaluate the effect of teaching strategies implemented, a test of nominal and functional level of scientific literacy was carried out on student teachers of both groups.

Step 5 – To test conceptual level of scientific literacy unit wise tests were carried out and evaluated.

Step 6 – To enhance conceptual level teaching strategies were implemented unit wise.

Step 7 – To check the effect of teaching strategies used to enhance conceptual level of scientific literacy, a test has been carried out on experimental group.

Step 8 – To test multidimensional scientific literacy levels certain topics from day to day life situations were selected and distributed among student teacher.

1) Student teachers were told to prepaid questioner with related to topic.

For example-topic selected Erection of biogas plant

Sample questions – Q. 1 What type of material can be used to erect gas storage tank?

Q. 2 What type of pipe can be used to circulate biogas inside home.

Those questioners were collected from students and analyzed their approach.

1) Test is prepaid by researcher by choosing the question from the questioner and used as pre test to evaluate multidimensional scientific literacy level of student teacher.

Step 9 – Teaching strategies were used to make them understand the situation and respond them.

Step 10 – Again post test carried out, to the cheek the response of student teacher on the same topic. To test the effect of teaching strategies on enhancement of multidimensional scientific literacy.

Step 11 – To test scientific process skills researcher prepaid and carried out the pre test on student teachers.

Step 12 – Small activity helpful to understand and implement scientific process skills were explained as well as how to answers the questions using scientific process skills was demonstrated.

Step 13 – To evaluate effect of teaching strategies post test has been carried out.

3.7.4 Daywise activities were carried out is given as below:
<table>
<thead>
<tr>
<th>Day</th>
<th>Unit</th>
<th>Levels of Scientific Literacy</th>
<th>Science Process Skills</th>
<th>Teaching Strategy</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Science an role of science teacher</td>
<td></td>
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<td>Interactive Lecture</td>
<td>5/11/2012</td>
<td>2:30 PM to 4:00 PM</td>
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<tr>
<td>Day 2</td>
<td>Nature of science</td>
<td>Conceptual level</td>
<td></td>
<td>Group discussion Interactive Lecture</td>
<td>6/11/2012</td>
<td>2:30 PM to 4:00 PM</td>
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<tr>
<td>Day 3</td>
<td>Levels of scientific literacy</td>
<td></td>
<td></td>
<td>Interactive Lecture Power point Presentation</td>
<td>7/11/2012</td>
<td>2:30 PM to 4:00 PM</td>
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<tr>
<td>Day 4</td>
<td>Scientific process skills</td>
<td></td>
<td></td>
<td>Group discussion Interactive lecture</td>
<td>8/11/2012</td>
<td>2:30 PM to 4:00 PM</td>
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<tr>
<td>Day 5</td>
<td>Pre Test on Physics</td>
<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
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<td>Questioning</td>
<td>26/11/2012</td>
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<tr>
<td>Day 6</td>
<td>Discussion on test (5 questions per day)</td>
<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
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<td>Interactive discussion Group discussion Interactive lecture</td>
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<td>Discussion on test (5 questions per day)</td>
<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
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<td>Interactive discussion Group discussion Interactive lecture</td>
<td>28/11/2012</td>
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<td>Day 8</td>
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<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
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<td>Interactive discussion Group discussion Interactive lecture</td>
<td>29/11/2012</td>
<td>2:30 PM to 4:00 PM</td>
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<td>Day 9</td>
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<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
<td></td>
<td>Interactive discussion Group discussion Interactive lecture</td>
<td>30/11/2012</td>
<td>2:30 PM to 4:00 PM</td>
</tr>
<tr>
<td>Day</td>
<td>Unit</td>
<td>Science Process Skills</td>
<td>Teaching Strategy</td>
<td>Date</td>
<td>Time</td>
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<td>Questioning</td>
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<td>Post Test on scientific process skills in physics</td>
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<td>Pre Test</td>
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<td>Questioning</td>
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<td>Post Test</td>
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<td>Questioning</td>
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<td>11</td>
<td>Unit - Measurement</td>
<td>Observation, Inference, Communication, Measuring, Prediction</td>
<td>Questioning</td>
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<td>12</td>
<td>Unit - Force and its types</td>
<td>Observation, Inference, Communication, Measuring, Classification, Prediction</td>
<td>Questioning</td>
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<tr>
<td>13</td>
<td>Unit - Simple Machines</td>
<td>Observation, Classification, Communication</td>
<td>Questioning 1. Questioning 2. Model presentation 3. Audio visual presentation 4. Interactive lectures 5. Hands on activity 6. Improving learning climate</td>
<td>5/12/2012</td>
<td>2:30 PM to 5:00 PM</td>
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<tr>
<td>Day</td>
<td>Unit</td>
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<td>Science Process Skills</td>
<td>Teaching Strategy</td>
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| 14   | Unit – Motion and types of motion Pre Test Post Test | Conceptual Scientific literacy level | Observation, Classification, communication | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 6/12/2012 | 2:30 PM to 5:00 PM |
| 15   | Unit – Work & Energy Pre Test Post Test          | Conceptual Scientific literacy level | Observation, Communication, measuring         | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 7/12/2012 | 2:30 PM to 5:00 PM |
| 16   | Unit – Light Pre Test Post Test                  | Conceptual Scientific literacy level | Observation, Communication, Inference         | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 10/12/2012 | 2:30 PM to 5:00 PM |
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<tr>
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<th>Unit</th>
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<th>Science Process Skills</th>
<th>Teaching Strategy</th>
<th>Date</th>
<th>Time</th>
</tr>
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</table>
| Day 17 | Unit – Magnetism Pre Test Post Test | Conceptual Scientific literacy level | Observation, Communication, Inference | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 11/12/2012 | 2:30 PM to 5:00 PM |
| Day 18 | Unit – Heat Pre Test Post Test | Conceptual Scientific literacy level | Observation, Communication, Inference, Prediction | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 12/12/2012 | 2:30 PM to 5:00 PM |
| Day 19 | Unit – Sound Pre Test Post Test | Conceptual Scientific literacy level | Observation, Communication, Inference | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 13/12/2012 | 2:30 PM to 5:00 PM |
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<th>Science Process Skills</th>
<th>Teaching Strategy</th>
<th>Date</th>
<th>Time</th>
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<td>4. Interactive lectures</td>
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<td>5. Hands on activity</td>
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<td>6. Improving learning climate</td>
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<td>Discussion on test (5 questions per day)</td>
<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
<td>Interactive discussion Group discussion Interactive Lecture</td>
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<td>Discussion on test (5 questions per day)</td>
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<td>Interactive discussion Group discussion Interactive Lecture</td>
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<td>21/12/2012</td>
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<tr>
<td>Day</td>
<td>Unit</td>
<td>Levels of Scientific Literacy</td>
<td>Science Process Skills</td>
<td>Teaching Strategy</td>
<td>Date</td>
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<td>Day 27</td>
<td>Post Test on Chemistry</td>
<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
<td>Scientific process skills</td>
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<td>24/12/2012</td>
<td>2:30 PM to 5:00 PM</td>
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| Day 28 | Unit – Classification of matter     | Conceptual Scientific literacy level | Observation, Communication, Inference | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 26/12/2012 | 2:30 PM to 5:00 PM |
| Day 29 | Unit – Atomic Structure              | Conceptual Scientific literacy level | Communication | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 27/12/2012 | 2:30 PM to 5:00 PM |
| Day 30 | Unit – Chemical Reactions            | Conceptual Scientific literacy level | Observation, Communication, Inference | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 28/12/2012 | 2:30 PM to 5:00 PM |
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<tr>
<th>Day</th>
<th>Unit</th>
<th>Levels of Scientific Literacy</th>
<th>Science Process Skills</th>
<th>Teaching Strategy</th>
<th>Date</th>
<th>Time</th>
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<tr>
<td>31</td>
<td>Unit- Acid and base Pre Test Post Test</td>
<td>Conceptual Scientific literacy level</td>
<td>Observation, Communication, Inference</td>
<td>1. Questioning</td>
<td>29/12/2012</td>
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<tr>
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<td>Unit –Metals and non metals Pre Test Post Test</td>
<td>Conceptual Scientific literacy level</td>
<td>Observation, Communication, Inference</td>
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<td>33</td>
<td>Unit- Carbon and its compounds Pre Test Post Test</td>
<td>Conceptual Scientific literacy level</td>
<td>Observation, communication</td>
<td>1. Questioning</td>
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<td>Post test on scientific process skill in Chemistry</td>
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<td>1/1/2013</td>
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<td>Day</td>
<td>Unit</td>
<td>Levels of Scientific Literacy</td>
<td>Science Process Skills</td>
<td>Teaching Strategy</td>
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<tr>
<td>Day 35</td>
<td>Pre Test on Biology</td>
<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
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<td>2/1/2013</td>
<td>2:30 PM to 5:00 PM</td>
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<td>Day 36</td>
<td>Discussion on test (5 questions per day)</td>
<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
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<td>Interactive discussion Group discussion Interactive Lecture</td>
<td>3/01/2013</td>
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<td>Day 37</td>
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<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
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<td>Interactive discussion Group discussion Interactive Lecture</td>
<td>04/01/2013</td>
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<td>Interactive discussion Group discussion Interactive Lecture</td>
<td>05/01/2013</td>
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<tr>
<td>Day 39</td>
<td>Discussion on test (5 questions per day)</td>
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<td>07/01/2013</td>
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<tr>
<td>Day 40</td>
<td>Post Test on Biology Pre Test on scientific process skills</td>
<td>Nominal Scientific literacy level &amp; Functional Scientific literacy level</td>
<td>scientific process skills</td>
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<td>08/01/2013</td>
<td>2:30 PM to 5:00 PM</td>
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<tr>
<td>Day 41</td>
<td>Unit – Characteristics of living organisms Pre Test Post Test</td>
<td>Conceptual Scientific literacy level</td>
<td>Observation, Communication, Inference</td>
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<td>09/01/2013</td>
<td>2:30 PM to 5:00 PM</td>
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<td>Day</td>
<td>Unit</td>
<td>Levels of Scientific Literacy</td>
<td>Science Process Skills</td>
<td>Teaching Strategy</td>
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<td>Day</td>
<td>Unit</td>
<td>Levels of Scientific Literacy</td>
<td>Science Process Skills</td>
<td>Teaching Strategy</td>
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<tr>
<td>Day 46</td>
<td>Unit – Blood Circulation</td>
<td>Conceptual Scientific literacy level</td>
<td>Observation, Communication</td>
<td>1. Questioning&lt;br&gt;2. Model presentation&lt;br&gt;3. Audio visual presentation&lt;br&gt;4. Interactive lectures&lt;br&gt;5. Hands on activity&lt;br&gt;6. Improving learning climate</td>
<td>17/01/2013</td>
<td>2:30 PM to 5:00 PM</td>
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<tr>
<td>Day 47</td>
<td>Unit – Control and Coordination</td>
<td>Conceptual Scientific literacy level</td>
<td>Observation, Communication</td>
<td>1. Questioning&lt;br&gt;2. Model presentation&lt;br&gt;3. Audio visual presentation&lt;br&gt;4. Interactive lectures&lt;br&gt;5. Hands on activity&lt;br&gt;6. Improving learning climate</td>
<td>18/01/2013</td>
<td>2:30 PM to 5:00 PM</td>
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<td>Day</td>
<td>Unit</td>
<td>Levels of Scientific Literacy</td>
<td>Science Process Skills</td>
<td>Teaching Strategy</td>
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| 48    | Unit – Food consumption, nutrition and food safety Pre Test Post Test | Conceptual Scientific literacy level | Observation, Communication, prediction           | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 19/01/2013 | 2:30 PM to 5:00 PM |
| 49    | Unit – Health, hygiene and diseases Pre Test Post Test | Conceptual Scientific literacy level | Observation, Communication, prediction           | 1. Questioning  
2. Model presentation  
3. Audio visual presentation  
4. Interactive lectures  
5. Hands on activity  
6. Improving learning climate | 21/01/2013 | 2:30 PM to 5:00 PM |
| 50    | Post test on scientific process skill in Biology | | Scientific process skill | Questioning                                                                 | 22/01/2013 | 2:30 PM to 5:00 PM |
| 51    | Questioning session regarding the tasks | Multidimensional scientific literacy level | | 1. Interactive lectures  
2. Group discussion | 23/01/2013 | 2:30 PM to 5:00 PM |
| 52    | Pre test on Multidimensional scientific literacy level | Multidimensional scientific literacy level | | Questioning                                                                 | 24/01/2013 | 2:30 PM to 5:00 PM |
|       | Topic on Erection of biogas plant | Multidimensional scientific literacy level | | 1. Expert Lecture  
2. Audio visual presentation | | |
### Levels of Scientific Literacy

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<tr>
<th>Day</th>
<th>Unit</th>
<th>Science Process Skills</th>
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<td>Topic on planning visit to sugarcane plant</td>
<td>Interactive Lecture</td>
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<td></td>
<td></td>
<td>2. Discussion on contemporary issues</td>
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<td>Day 54</td>
<td>Topic on fixing flat tyres</td>
<td>Interactive Lecture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Discussion on contemporary issues</td>
</tr>
<tr>
<td>Day 55</td>
<td>Topic on building fish tank in home</td>
<td>Interactive Discussion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Audio visual presentation</td>
</tr>
<tr>
<td>Day 56</td>
<td>Topic on designing juicer</td>
<td>Interactive Discussion</td>
</tr>
<tr>
<td></td>
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<td>2. Questioning</td>
</tr>
<tr>
<td></td>
<td>Post test</td>
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### Date 28/01/2013 to 31/01/2013

### Time 2:30 PM to 5:00 PM

In this chapter, the researcher has described research method, research design, sampling procedure and tools of data collection with respect to present study. In the chapter fourth researcher has explained development of teaching strategies enhancing scientific literacy and scientific process skills.