CHAPTER – III

METHODOLOGY

This chapter deals with the methodological procedures adopted in the study. It includes design of the study, sampling procedure, development of tools and procedural details of the experimental intervention.

3.1 DESIGN OF THE STUDY

The study is quasi-experimental in nature wherein a pretest-posttest non-equivalent groups design was employed. The pretest-posttest non-equivalent groups design is often used in classroom experiments when experimental and control groups are such naturally assembled groups as intact classes, which may be similar (Best & Kahn, 2006). Quasi-experimental designs are ‘almost’ true experimental designs except that the participants are not randomly assigned to groups (Mertens, 1998). A quasi-experiment is an approximation of a true experiment that uses groups that have not been formed randomly (Wiersma & Jurs, 2009). In this research, the investigator selected intact groups rather than randomly assigning participants to the experimental or control groups, since assigning participants randomly to the groups disturbs the routine of the class schedule. The researcher was unable to randomly assign schools because the control group should be deprived of the online learning platform accessibility. Otherwise it may contribute to contamination effect and in turn affect experimental validity. Best and Kahn (2006) observed that if quasi-experimental design is the only feasible one, the comparison is justifiable.

As mentioned, the study adopted a pretest-posttest non-equivalent groups design. Pretests on critical thinking, problem solving, science process skills and science achievement were administered to both the experimental and control group. Then, the experimental group was taught using blended learning strategy, whereas the control group was taught by the regular teacher using the conventional teaching method. Then posttests were administered to both the groups. The design is symbolically represented and outlined in the following table.
\[ O_1 \quad X \quad O_2 \quad \text{where } O_1 \text{ and } O_3 = \text{Pretests} \]
\[ O_3 \quad C \quad O_4 \quad O_2 \text{ and } O_4 = \text{Posttests} \]
\[ X = \text{Experimental treatment} \]
\[ C = \text{Conventional teaching} \]

**Table 3.1: Design of the Study**

<table>
<thead>
<tr>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretests</td>
<td>Pretests</td>
</tr>
<tr>
<td>Blended learning strategy</td>
<td>Conventional teaching</td>
</tr>
<tr>
<td>Posttests</td>
<td>Posttests</td>
</tr>
</tbody>
</table>

### 3.2 SAMPLING

Secondary school students were chosen as the population. Purposive sampling technique was employed in selecting the schools. Two CBSE affiliated schools were selected from Bangalore city for the study, one school having the provision of online learning platform ‘www.thinkquest.org’ (formerly known as ‘www.‘thinkquest.org’) and another school without that facility.

Balagangadaranatha Swami [BGS] National Public School, in which the online learning platform is available, was selected for the experimental intervention. The intact group of 38 ninth standard students of the school was regarded as the experimental group. All students of BGS National Public School are enrolled in www.thinkquest.org and are having access to the learning materials available on www.thinkquest.org. The other section of BGS National Public School was not selected as the control group since this could have contributed to contamination effect which in turn, would affect experimental validity.

The access of the online platform www.thinkquest.org is available to students only if the school is enrolled in www.thinkquest.org. Therefore, the researcher decided to select the control group from a school which is not enrolled in www.thinkquest.org. The intact group of 36 Ninth standard students of Jyoti Kendriya Vidyalaya, Bangalore was selected as the control group since Jyoti Kendriya Vidyalaya is not enrolled in www.thinkquest.org. This ensured that the control group students’ access to learning materials through the online platform was completely controlled since the control group students do not have access to www.thinkquest.org either in the school or outside the school.
Ninth standard students were considered for the study because schools are reluctant in giving permission to conduct any type of intervention to tenth standard students as the teachers are preparing these students for the CBSE exam.

The experimental group and the control group are comparable in the following aspects.

- Both the schools are located in Bangalore city, 5 km apart
- Both the schools are affiliated to Central Board of Secondary Education (CBSE)
- National Council of Educational Research and Training (NCERT) science text books are being used in both the schools for transaction
- In both the schools, the medium of instruction is English
- Both the schools are co-educational institutions
- Both the schools have similar infrastructure facilities (science lab, computer lab etc) except that the experimental school has the online learning platform
- The admission procedures followed in both the schools are similar
- Students of different sections of ninth standard were not placed according to ability grouping in both the schools. Therefore random selection of the sections of ninth standard from the schools for the study assures inclusion of differentially abled students
- Students of both experimental and control group are having comparable ability level as their age group is 14-15
- The classroom strength was almost equal - 38 in the experimental group and 36 in the control group

3.3 PREPARATION AND VALIDATION OF TOOLS

Tests to assess critical thinking, problem solving, science achievement and science process skills were prepared and validated. In addition, a learning style inventory to identify learning style of students, a reaction scale to find reaction of students towards blended learning strategy and a semi-structured interview to analyze the difficulties faced by students while learning through blended learning strategy were also prepared.
3.3.1 Steps Followed in Preparation and Validation of Tests (Critical Thinking Test, Problem Solving Test, Science Process Skills Test and Science Achievement Test)

The steps suggested by Transler and North (as cited in Kishan, 2008) were followed in the preparation and validation of the tests.

1. Survey of sub-areas in the subject field
2. Preparation of test items
3. Critical evaluation of test items by experts
4. Formulating precise instructions for administration and preparation of scoring key
5. Tryout of the trial form
6. Item analysis to determine difficulty level and discriminative index
7. Establishing reliability of the test

The adaptation of the above guidelines for the preparation of each test used in the study is described in the following sections.

3.3.2 Preparation and Validation of Critical Thinking Test

According to American Philosophical Association (APA, 1990), critical thinking refers to purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference as well as explanation. In the present study, cognitive skills of critical thinking such as interpretation, analysis, evaluation, inference, explanation and self-regulation were considered.

The review of related literature provided information on the various modes of assessment of critical thinking. Review of literature on tools of critical thinking revealed that there are very few tools available to assess critical thinking. The tools like Watson Glaser Critical Thinking Appraisal, Cornell Critical Thinking Test Series and Ennis-Weir Critical thinking Essay Test are the most commonly used tools. But these tools either were not suitable to the age level of ninth standard students or the dimensions of critical thinking identified and considered for the present study were not assessed by these existing tools. Moreover, these tests were discipline-neutral, not domain specific. The researcher, after discussion with experts, reached a consensus that it is better to test the critical thinking skills of students through domain specific items. Within curricular programs, discipline specific critical thinking assessment is encouraged, since it is possible for one to be fair in one’s presumptions regarding subject-specific criteria, methodologies, concepts, evidence, information
and terminology (APA, 1990). Based on the above considerations, the researcher prepared ‘Critical Thinking Test’ consisting domain specific items.

The recommendation given in the Delphi report on critical thinking by APA explicitly states that in evaluating the acceptability of critical thinking assessment strategy or instrument, one should consider content validity, construct validity, fairness and reliability. Detailed reviews of literature available on critical thinking, exploratory discussion with the experts in the field and their opinion on test items helped the researcher to establish content validity and fairness of the test. Reliability of the tool was established by conducting the test to a fairly large sample of 94 students of ninth standard. The reliability was estimated using Cronback Alpha and the value was found to be 0.7. The description of the Preparation of ‘Critical Thinking Test’ is detailed in following section.

**Steps followed in the Preparation and Validation of Critical Thinking Test**

Steps suggested by Transler and North (cited in Kishan, 2008) were followed in preparation and validation of the critical thinking test and details are given below.

**1. Survey of sub-areas in the subject field**

Literature review on critical thinking was done to identify the skills to be assessed in critical thinking test and to familiarize with the assessment procedures of critical thinking. Especially, literatures available in the ‘Centre for Critical Thinking and Moral Critique’ website, a book titled ‘Critical Thinking Handbook: High School, A Guide for Redesigning Instruction’ published by Paul, Martin, and Adamson in 1989 and various literatures available in the critical thinking community website run by Sonoma State University (http://www.criticalthinking.org) were reviewed to have better understanding of different dimensions of critical thinking. Different theses published on critical thinking such as Reed (1998) and Smitha (2008) were reviewed. By reviewing APA Delphi research report published in 1990, researcher identified critical thinking dimensions such as interpretation, analysis, evaluation, inference, explanation, self-regulation and considered them for inclusion in the Critical Thinking Test.

Consensus descriptions of critical thinking cognitive skills as given in the Delphi report (APA, 1990) are given in the following table and these descriptions served as the basis for formulating the objectives that helped in constructing a framework from which items could be drawn.
<table>
<thead>
<tr>
<th>Components of Critical Thinking</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpretation</td>
<td>To comprehend and express the meaning or significance of a wide variety of experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures or criteria</td>
</tr>
<tr>
<td>Analysis</td>
<td>To identify the intended and actual inferential relationships among statements, questions, concepts, descriptions or other representation intended to express beliefs, judgments, experiences, reasons, information or opinions</td>
</tr>
<tr>
<td>Evaluation</td>
<td>To assess the credibility of statements or other representations which are accounts or descriptions of a person’s perception, experience, situation, judgment, belief or opinion; and to assess the logical strength of the actual or intend inferential relationships among statements, descriptions, questions or other forms of representation</td>
</tr>
<tr>
<td>Inference</td>
<td>To identify and secure elements needed to draw reasonable conclusions, to form conjectures and hypotheses, to consider relevant information and to deduce the consequences flowing from data, statements, principles, evidences, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation</td>
</tr>
<tr>
<td>Explanation</td>
<td>To state the results of one’s reasoning; to justify that reasoning in terms of the evidential, conceptual, methodological, criteriological and contextual considerations upon which one’s results were based; and to present one’s reasoning in the form of cogent arguments</td>
</tr>
<tr>
<td>Self-Regulation</td>
<td>Self-consciously monitor one’s own cognitive activities, the elements used in those activities, and the results educed, particularly applying skills in analysis and evaluation to one’s own inferential judgments with a view toward questioning, confirming, validating or correcting either one’s reasoning or one’s results.</td>
</tr>
</tbody>
</table>
2. Preparation of test items

Twenty test items were prepared on the six dimensions of critical thinking. While preparing the items, special care was taken to not unfairly disadvantage or advantage groups of students on the basis of their reading ability, domain specific knowledge, gender or socio economic status.

3. Critical evaluation of test items by experts

The tool was presented to a panel of experts to determine the representativeness of the items. Content validation is the process of establishing the representativeness of the items with respect to the domain of skills, tasks, knowledge and so forth of whatever is being measured (Wiersma & Jurs, 2009). Content validity and the logical analysis of the items determines their representativeness. Each task or question in a critical thinking assessment should be evaluated to ensure that correctly responding to that item is not a matter of rote learning or information recall (APA, 1990). A panel of experts in the field who judge the tests’ adequacy often assesses the content, but there is no numerical way to express it (Best & Kahn, 2006).

The tool with 20 items were presented to a panel of 12 experts which included eight teacher educators, two research scholars and two science teachers. The panel of experts was requested to give suggestions and comments on issues of the actual wording, the design of the items and how adequately the test represents the universe of critical thinking that a student is expected to master. Based on their feedback and suggestions, items were refined. After the review of the test items by the panel of experts, two items were rejected, three items were accepted with modification and 15 items were retained as such. Therefore at this stage of tool preparation, 18 items were retained in the critical thinking test.

4. Formulating precise instructions for administration and preparation of scoring key

In the critical thinking test, instructions were written in simple language. It was mentioned clearly that each item begins with certain situations or scenarios followed by multiple choice question/s. The respondents would be expected to select one of the four options given for each multiple choice question. Separate answer sheets would be provided to students to mark their response. Scoring key of the test was also prepared.
5. Tryout of the trial form

The test with 18 items was administered to 94 students of Kendriya Vidyalaya, Payyanur who were about to complete ninth standard. The students were not randomly selected from the population of the study, but they were familiar with the variables under study. The group used for pilot run need not be a random sample of prospective respondents, but the members of the group should be familiar with the variables under study and should be in a position to make valid judgments about the items (Wiersma & Jurs, 2009). As a means of eliminating faulty items and improving the quality of items, it was felt necessary to subject the proposed items to empirical trial with students similar to those who are going to use the final form of the test. The interaction with the students during the pilot run helped the researcher to identify certain misunderstandings, ambiguities and difficulties in understanding the items/instructions. On the basis of the feedback, necessary revisions were made to the critical thinking test. The average time taken by the students to complete the test was 45 minutes. Therefore the time duration for the test was fixed as 45 minutes.

6. Item analysis to determine Difficulty Level and Discriminative Index

The Administered test was scored and total score of each student in the test was calculated. The scores were arranged in the descending order of their total score. Top 27% of the students were identified as the upper group and the bottom 27% were identified as the lower group. The data obtained from this exercise was used to determine the Difficulty Value and Discriminative Index of the items.

Difficulty Value (D.V.) refers to proportion of the total group who got the item right. Thus a high value indicates an easy item and a low value indicates a difficult item. The Difficulty Value of an item is calculated using the formula:

\[ D.V. = \left( \frac{U - L}{N} \right) \times 100 \]

Where,
- \( U \) = Number of right responses in the upper group
- \( L \) = Number of right responses in the lower group
- \( N \) = Number of students in either upper or lower group
Ebel (1965) suggests that a test item which has difficulty index value ranging from 20 to 80 is acceptable for a test.

If the test and an item measure the same ability or competence, we would expect that those having a high overall test score would have a high probability of being able to answer the item. We would also expect the opposite, which is to say that those having low test scores would have a low probability of answering the item correctly. Thus, a good item should discriminate between those who score high on the test and those who score low. The higher the Discriminative Index, the better the item can determine difference between those with high test scores and those with low ones. Discriminative Index of an item is calculated using the formula:

$$D.I. = \frac{U + L}{2N}$$

Ebel (1965) has suggested a reasonable criterion to use Discriminative Index as given in the following table.

**Table 3.3: Discriminative Indices and Item Evaluation**

<table>
<thead>
<tr>
<th>Discriminative Index</th>
<th>Item Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40 and above</td>
<td>Very good items</td>
</tr>
<tr>
<td>0.30 to 0.39</td>
<td>Reasonably good but possibly subject to improvement</td>
</tr>
<tr>
<td>0.20 to 0.29</td>
<td>Marginal items usually needing and being subjected to improvement</td>
</tr>
<tr>
<td>0.19 and Below</td>
<td>Poor item to be rejected or improved by revision</td>
</tr>
</tbody>
</table>

Difficulty Values and Discriminative Indices of each item in the critical thinking test are given in the Appendix-1. After item analysis, all the 18 items were retained in the critical thinking test as values of D.V. and D.I. of all the items satisfied the above mentioned criteria of acceptance.

**7. Establishing reliability of the test**

Reliability is the consistency of the instrument in measuring whatever it measures (Wiersma & Jurs, 2009). The reliability of the critical thinking test was estimated using Cronbach Alpha and was found to be 0.7. Cronbach Alpha reliability coefficient normally ranges between 0 and 1. The closer Cronbach Alpha Coefficient is to 1.0, the greater the internal consistency of the items in the scale.
Based upon the formula:

\[
\alpha = \frac{rk}{[1+(k-1)r]}
\]

where k is the number of items considered and r is the mean of the inter-item correlations, the size of Alpha is determined by both the number of items in the scale and the mean inter-item correlations.

George and Mallery (2003) provided the following rules of thumb for determining the acceptability of the test with respect to the value of Cronbach Alpha:

**Table 3.4: Cronbach Alpha Coefficient and Acceptability of the Test**

<table>
<thead>
<tr>
<th>Cronbach Alpha Coefficient</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than or equal to 0.9</td>
<td>Excellent</td>
</tr>
<tr>
<td>Greater than or equal to 0.8</td>
<td>Good</td>
</tr>
<tr>
<td>Greater than or equal to 0.7</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Greater than or equal to 0.6</td>
<td>Questionable</td>
</tr>
<tr>
<td>Greater than or equal to 0.5</td>
<td>Poor</td>
</tr>
<tr>
<td>Less than or equal to 0.5</td>
<td>Unacceptable</td>
</tr>
</tbody>
</table>

Since the Cronbach Alpha Coefficient of the critical thinking test was found to be 0.7, the critical thinking test was found to have acceptable measure of reliability.

Finally, the critical thinking test consisted of 18 items. The different dimensions of critical thinking and the corresponding test items are given in Appendix-15.

### 3.3.3 Preparation and Validation of Problem Solving Test

The cognitive processes that are associated with problem solving are diverse and complex. How familiar the context is to the target, whether the problem involves concrete tasks or complex actions, how well the goal is defined, how many elements the problem solver has to take into account and how strongly they are interconnected etc. are some of the factors which determine the level or extent of problem solving. Therefore the process of constructing an instrument which assesses problem solving becomes difficult and identifying the elements or components of problem solving requires careful and thorough analysis. The other consideration that arises in the preparation of problem solving tool is whether the tool should be content specific or generic in nature. A problem solving test is prepared by taking these points into
consideration and the steps involved in the preparation of problem solving test are detailed in the following section.

**Steps Followed in the Preparation and Validation of Problem Solving Test**

Steps suggested by Transler and North (as cited in Kishan, 2008) were followed in the preparation and validation of the problem solving test and the details are given below.

1. **Survey of sub areas in the subject field**

   A review on problem solving was done to familiarize with the assessment procedures of problem solving and to identify the skills to be assessed in problem solving tests. The survey was mainly based on different frameworks and procedures used in the assessment of problem solving, such as, framework developed by Reeff and Blech (2006) for German Institute for Adult Education (DIE), sponsored by German Federal Ministry for Education and Research (BMBF). A tool developed by Lori and Warfield (1999), as part of action research project on ‘improving the problem solving skills of Math and Science Students at the High School level’ was reviewed by the researcher to understand the structure of problem solving tests. In 2003, Organization for Economic Cooperation and Development (OECD), through Program for International Student Assessment (PISA), assessed students’ abilities in problem solving using items which required students to apply various reasoning processes, such as inductive and deductive reasoning, reasoning about cause and effect or combinational reasoning. Though there are various tools available to assess problem solving, it was decided to construct a problem solving test specifically tailored for testing problem solving of secondary school students based on domain specific items.

   A thesis on problem solving published by Praveen (1998) was reviewed. Comprehending the problem, clarifying the problem and finding solution to the problem were validated as the components of problem solving in the thesis. These were selected as the dimensions to be assessed in the problem solving test in the present study. The dimensions and subcomponents of problem solving selected for the problem solving test are presented in the following table.
<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Subcomponents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehending the problem</td>
<td>• Sensing a problem</td>
</tr>
<tr>
<td></td>
<td>• Defining a problem</td>
</tr>
<tr>
<td></td>
<td>• Analysis of problem into discrete elements</td>
</tr>
<tr>
<td>Clarifying the problem</td>
<td>• Ability to discriminate between the most relevant and closely related concepts</td>
</tr>
<tr>
<td></td>
<td>• Using analogies for reasoning</td>
</tr>
<tr>
<td></td>
<td>• Using inductive/deductive reasoning</td>
</tr>
<tr>
<td></td>
<td>• Hypothesizing</td>
</tr>
<tr>
<td></td>
<td>• Checking the testability of hypothesis</td>
</tr>
<tr>
<td>Finding solutions to the problem</td>
<td>• Controlling of variables</td>
</tr>
<tr>
<td></td>
<td>• Prediction</td>
</tr>
<tr>
<td></td>
<td>• Conceiving ideas using diagrammatic representation</td>
</tr>
<tr>
<td></td>
<td>• Conceiving a strategy to execute a plan of action to test the hypothesis</td>
</tr>
<tr>
<td></td>
<td>• Drawing inference from relevant observed data</td>
</tr>
<tr>
<td></td>
<td>• Generalizing</td>
</tr>
</tbody>
</table>

2. Preparation of test items

Thirty-two test items were prepared on the above mentioned dimensions of problem solving. While preparing the items special care was taken to not unfairly disadvantage or advantage groups of students on the basis of their reading ability, domain specific knowledge, gender or socio-economic status.

3. Critical evaluation of test Items by experts

The tool with 32 items were presented to a panel of 12 experts which included eight teacher educators, two research scholars and two school science teachers. The panel of experts was requested to give suggestions and comments on issues of the actual wording, the design of the items and how adequately the test represents problem solving skills that a student is expected to master. Based on their feedback and suggestions, items were refined. After the critical evaluation of the test items by
the panel of experts, five items were rejected and 27 items were retained as such. Therefore at this stage of tool preparation, 27 items were retained in the problem solving test.

4. Formulating precise instructions for administration and preparation of scoring key

In the problem solving test, instructions were written in simple language. It was mentioned clearly that each item begins with certain situations or scenarios followed by multiple choice question/s. The respondents would be expected to select one of the four options given for each multiple choice question. Separate answer sheets would be provided to students to mark their response. Scoring key of the test was also prepared.

5. Tryout of the Trial Form

The test with the 27 items was administered to 94 ninth students of Kendriya Vidyalaya, Payyanur. The interaction with the students during the pilot run helped the researcher to identify certain misunderstandings, ambiguities and difficulties in understanding the items/instructions. On the basis of the feedback, necessary revisions were made to the problem solving test. The average time taken by the students to complete the test was 45 minutes. Therefore, the time duration for the test was fixed as 45 minutes.

6. Item analysis to determine Difficulty Level and Discriminative Index

The scoring of the administered test was done and the total score of each student in the test was calculated. The data was arranged in the descending order of their total score. Top 27% of the students were identified as the upper group and the bottom 27% were identified as the lower group. The data obtained from this exercise was used to determine Difficulty Value and Discriminative Index of the items.
The Difficulty Value of an item is calculated using the formula:

\[
D.V. = \left( \frac{U - L}{N} \right) \times 100
\]

and Discriminative Index of an item was calculated using the formula:

\[
D.I. = \frac{U + L}{2N}
\]

Details of D.V and D.I are given in section 3.3.2

The Difficulty Values and Discriminative Indices of the 27 items of the problem solving test are given in Appendix-2. Two items were deleted and 25 items were retained based on the values of D.V. and D.I.

7. Establishing reliability of the test

The reliability of the developed tool was estimated using Cronbach Alpha. Cronbach Alpha coefficient was found to be 0.73 and hence the problem solving test was found to have acceptable measure of reliability. Finally, the problem solving test consists of 25 items. The different dimensions of problem solving and the corresponding test items are given in Appendix-16.

3.3.4 Preparation and Validation of Science Process Skills Test

Science process skills are set of skills which are underlined in the process of acquiring scientific knowledge. A science process skill test was prepared by considering various science process skills and its various modes of assessment. The steps followed in the preparation of science process skill test are detailed below.

Steps followed in the Preparation and Validation of Science Process Skills Test

The steps suggested by Transler and North (as cited in Kishan, 2008) were followed in the preparation and validation of science process skill test.

1. Survey of sub-areas in the subject field

Literature review on science process skills was done to identify the skills to be assessed in science process skill test and to familiarize with the assessment procedures
of science process skills. Publications of ‘American Association for the Advancement of Science’, documents produced by UNESCO (as cited in Staver, 2007) were reviewed to have better understanding on science process skills. Different research works published on science process skills (Lanka, 2007), Marshall (1991) and Foulds and Rowe (1996), were also reviewed for a better understanding of the skills underlined in science process skills and its various modes of assessment. Existing tools for assessing science process skills such as Test of Integrated Process Skills (TIPS) developed by Burns, Okey and Wise (1985) and other science process skill tests developed by researchers (Tannenbaum, 1971 & Sridevi, 2008) were also reviewed.

After discussions with experts, the researcher reached a consensus that only basic science process skills are to be considered for assessment since most of the integrated science process skills overlap with critical thinking and problem solving. To avoid the overlap with the other dependent variables of the study, it was decided to include only basic science process skills in the test.

The review of related literature revealed that the following assessment techniques are in common use for assessing science process skills.

- Evaluation of laboratory reports made by the learners on the basis of their laboratory experiences
- Individual learner projects based on practical skills
- Paper and pencil test items pertaining to laboratory experiences and related issues
- Practical examinations

The researcher decided to conduct paper and pencil test items to assess science process skills because of its ease of administering and assessing both pretest and posttest. A detailed review revealed that several studies were conducted in which paper pencil tests were used to measure science process skills such as in Sridevi (2008). In addition to this, Second International Science Study (SISS) (as cited in Tamir, Dorant & Chye, 1992) used paper and pencil tests to measure science process skills. Considering the age level of the learners and ease of assessment through paper pencil test, the investigator selected the following basic science process skills.

1. Observing
2. Comparing
3. Classifying
4. Quantifying
5. Communicating
6. Predicting

These skills were validated by Tannenbaum (1971), Bhatt (1983) and the commission on Science Education of the American Association for the Advancement of Science (1961).

The indicators of the selected basic science process skills are given in the following table.

**Table 3.6: Science Process Skills and their Indicators**

<table>
<thead>
<tr>
<th>Science Process Skills</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observing</td>
<td>Identify properties of an object i.e. shape, colour, size and texture using senses, use indirect methods, that is microscope, thermometer, measuring jar etc to observe objects and events, identify patterns, identify quantitative and qualitative changes in conditions</td>
</tr>
<tr>
<td>Comparing</td>
<td>Discriminating objects by their properties like length, area, weight etc, relating objects or events to each other based on similarities or differences</td>
</tr>
<tr>
<td>Classifying</td>
<td>Identify properties useful for classifying objects, group or sort objects by their properties or similarities and differences</td>
</tr>
<tr>
<td>Quantifying</td>
<td>Express as a number, or measure or quantity</td>
</tr>
<tr>
<td>Communicating</td>
<td>Construct and use written reports, diagrams, graphs, charts, pictures or equations to transmit information to others</td>
</tr>
<tr>
<td>Predicting</td>
<td>Forecast a future event based upon prior experiences, that is observations, inferences or experiments.</td>
</tr>
</tbody>
</table>

2. Preparation of test items

Forty test items were prepared based on the above mentioned indicators of six basic science process skills. The items were content specific and were prepared based on the six selected science units of ninth standard. While preparing the items, special care was taken to not unfairly disadvantage or advantage groups of students on the basis of their reading ability, domain specific knowledge, gender or socio-economic status.
3. Critical evaluation of test items by experts

The tool with 40 items were presented to a panel of 12 experts which included eight teacher educators, two research scholars and two school science teachers. The panel of experts was requested to give suggestions and comments on issues of the actual wording and design of the items. Experts were asked to map the test items with the specific process skill which the item was intended to measure. Based on their feedback and suggestions, items were refined. After the critical evaluation of the test items by the panel of experts, two items were rejected, two items were accepted with modification and 36 items were retained as such. Therefore at this stage of tool preparation, 38 items were retained in the science process skill test.

4. Formulating precise instructions for administration and preparation of scoring key

In the science process skill test, instructions were written in simple language. It was mentioned clearly that each item begins with certain situations or scenarios followed by multiple choice question/s. The respondents would be expected to select one of the four options given for each multiple choice question. Separate answer sheets would be provided to students to mark their response. Scoring key of the test was also prepared.

5. Tryout of the trial form

The test with 38 items was administered to 94 ninth standard students of Kendriya Vidyalaya, Payyanur. The interaction with the students during the pilot run helped the researcher to identify certain misunderstandings, ambiguities and difficulties in understanding the items/instructions. On the basis of the feedback, necessary revisions were made to the science process skill test. The average time taken by the students to complete the test was 45 minutes. Therefore, the time duration for the test was fixed as 45 minutes.

6. Item analysis to determine difficulty level and discriminative index

The scoring of the administered test was done and the total score of each student in the test was calculated. The data was arranged in the descending order of their total score. Top 27% of the students were identified as the upper group and the bottom 27% were identified as the lower group. The data obtained from this exercise
was used to determine Difficulty Value and Discriminate Index of the items. The Difficulty Value and Discriminative Index of each item was calculated and based on that, items were selected.

The Difficulty Values and Discriminative Indices of 38 items in the science process skill test are given in the Appendix-3.

7. Establishing reliability of the test

The reliability of the developed tool was estimated using Cronbach Alpha and was found to be 0.86. Hence the science process skill test was found to have acceptable measure of reliability. Finally, the science process skill test consisted of 34 items. The different dimensions of science process skills and the corresponding test items are given in the Appendix-17.

3.3.5 Preparation and Validation of Science Achievement Test

Science achievement tests are designed to measure knowledge as well as the ability to use scientific knowledge. They may deal with knowledge of facts and principles as well as the ability to apply them in complex and usually life like situations (Payne, 1992).

Steps followed in the Preparation and Validation of Science Achievement Test

The steps suggested by Transler and North (as cited in Kishan, 2008) were followed in the preparation and validation of the science achievement test.

1. Survey of sub areas in the subject field

Available literature on science achievement was reviewed to familiarize with the assessment procedures of science achievement. Publications like ‘benchmarks for Science Literacy-Project 2061’ by American Association for the Advancement of Science (1993), Handbook for Science teachers (UNESCO, 1980), publications of ‘International Association for the Evaluation of Educational Achievement’ such as ‘Science Education in 19 countries’ (Comber & Keeves, 1973) were reviewed. Various theses published on science achievement were reviewed to understand various modes of assessment of achievement in science. It was decided to include items from the six selected science units of ninth standard.
2. Preparation of test items

121 test items were prepared on all the six units of ninth standard science. While preparing the items special care was taken to not unfairly disadvantage or advantage groups of students on the basis of their reading ability, domain specific knowledge, gender or socio economic status.

3. Critical evaluation of test items by experts

The science achievement test with 121 items was submitted to a group of 18 Pre University College lecturers of science who attended a workshop on ‘constructing multiple choice items in science’ at RIE, Mysore with a request to provide suggestions on the structure and appropriateness of the test items. Suggestions given by the lecturers were incorporated and the tool with 97 items were presented to a panel of 12 experts which included eight teacher educators, two research scholars and two school science teachers. The panel of experts was requested to give suggestions and comments on issues of the actual wording, the design and the adequacy of the test items. Based on their feedback and suggestions, 25 items were rejected and therefore at this stage of tool preparation, 72 items were retained.

4. Formulating precise instructions for administration and preparation of scoring key

In the science achievement test, instructions were written in simple language. It was mentioned clearly that each item begins with certain situations or scenarios followed by multiple choice question/s. The respondents would be expected to select one of the four options given for each multiple choice question. Separate answer sheets would be provided to students to mark their response. Scoring key of the test was also prepared.

5. Tryout of the trial form

The test with 72 items was administered to 94 students of Kendriya Vidyalaya, Payyanur who were about to complete ninth standard. The interaction with the students during the pilot run helped the researcher to identify certain misunderstandings, ambiguities and difficulties in understanding the items/instructions. On the basis of the feedback, necessary revisions were made to the
science achievement test. The average time taken by the students to complete the test was 45 minutes. Therefore, the time duration for the test was fixed as 45 minutes.

6. Item Analysis to determine difficulty level and discriminative index

The scoring of the administered test was done and the total score of each student in the test was calculated. The data was arranged in the descending order of their total score. Top 27% of the students were identified as the upper group and the bottom 27% were identified as lower group. The data obtained from this exercise was used to analyse the Difficulty Value and Discriminative Index of the items.

The Difficulty Values and Discriminative Indices of items are provided in the Appendix-4. Based on the Difficulty Values and Discriminative Indices, 50 items were selected for the test.

7. Establishing reliability of the test

The reliability of the developed tool was estimated using Cronbach Alpha and since the coefficient was found to be 0.87, the tool was accepted. Finally, the science achievement test consists of 50 items with proper weightage to different units and objectives. The details regarding the distribution of questions are given in Appendix-18.

3.3.6 Preparation of Reaction Scale to find out students’ reaction towards Blended Learning Strategy

A questionnaire to find views towards blended learning developed by Buket and Meryem (2006) was modified appropriately to seek students’ reaction to the blended learning strategy implemented by the researcher in the present study. Consent was taken from the authors of the questionnaire to use the same for the present study. The dimensions of the tool were retained as such. However, the number of questions and the wordings of some of the items under each dimension were changed. The dimensions of the reaction scale are:

- Ease of use for web environment
- Online Environment
- Content
- Evaluation
- Learners’ views on blended learning in general
The reaction scale prepared based on the above mentioned dimensions was determined to have a 3 point scale with 1 as ‘not at all true’, 2 as ‘partially true’ and 3 as ‘totally true’. The reaction scale consists of 40 items at this stage. Content validity was established by eight experts including two experienced professionals from Information Technology field, one research scholar working in ICT in Education, three teacher educators and two school teachers who are exposed to online learning using thinkquest platform. Based on their suggestions, five items were deleted and 35 items were retained in the reaction scale. It was administered to five students who were exposed to the experimental intervention. Interaction with those students helped the researcher to check the clarity and comprehensibility of the items and the time duration of the test. Since the average time taken by students to complete the reaction scale was 30 minutes, the duration was fixed to be 30 minutes. Due to the unavailability of students who were exposed to blended learning strategy, the researcher was unable to administer the tool to a fairly large group similar to the sample for estimating the reliability of the tool.

3.3.7 Preparation of Learning Style Inventory

A Learning Style Inventory was developed by the researcher to identify students’ learning style-Visual, Auditory or Kinesthetic. Since the blended learning strategy gives impetus to different modalities of teaching/learning, the researcher decided to consider Visual, Auditory and Kinesthetic learning styles as the dimensions of learning style inventory. The learning styles and the indicators are given in the following table.

Table 3.7: Learning Styles and their Descriptions

<table>
<thead>
<tr>
<th>Learning Styles</th>
<th>Descriptions/Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>The use of seen or observed things, including pictures, diagrams, demonstrations, displays, handouts, films, flip-charts, etc.</td>
</tr>
<tr>
<td>Auditory</td>
<td>The transfer of information through listening: via the spoken word, of self or others, of sounds and noises.</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>The physical experience – touching, feeling, holding, doing, practical hands-on experiences.</td>
</tr>
</tbody>
</table>
The researcher reviewed different learning style inventories available, including learning style inventories which are accessible online. Since validated learning style inventory to identify Visual, Auditory and Kinesthetic learning style of secondary school students was unavailable, it was decided to develop a learning style inventory to assess the same. Review of literature on learning style was done and tools like Barsch’s learning Style Inventory and Style of Learning and Thinking (SOLAT) were reviewed.

After reviewing different books and journals, the characteristics of people with Visual, Auditory and Kinesthetic learning styles were listed. Items were prepared based on this list. About 35 items were pooled in this stage. Students were asked to mark their preference out of the three options, in which each option characterizes each learning style. The inventory was submitted to a panel of 10 experts including five teacher educators, three teachers and two research scholars with a request to scrutinize the statements for their clarity, relevance and appropriateness to the secondary school students. The experts were requested to rate each statement on three categories as ‘essential’, ‘useful but not essential’ and ‘not necessary’. The feedback offered by the experts was considered and incorporated.

This was administered to 31 ninth standard students of Demonstration Multipurpose School, Mysore. Interaction with students helped the researcher to identify their difficulty in answering the items, to ensure comprehensibility of the items and to determine the time duration of the test. Based on their feedback, some of the items were deleted and necessary modifications were made to some of the items and the tool was finalized. Moreover, the researcher tried to triangulate the result obtained through the learning style inventory by interacting with the parent of a student who participated in the pilot run of the tool, about the learning style of his child. The parent was a teacher educator-cum-expert in learning style. Finally the learning style inventory has 20 items with single stem and three preferences belonging to Visual, Auditory and Kinesthetic learning styles. Students were asked to mark any one among them as their preference. Clear instructions with example for marking their preference were provided in the tool. It was decided to determine the learning style of students by estimating the number of preferences under each category. The category in which a student scored the maximum is regarded as the dominant learning style of that student. The duration for completing the learning style inventory was decided to be 20 minutes.
3.3.8 Preparation of Semi-Structured Interview Schedule

A semi-structured interview schedule was prepared to find the difficulties faced by students while learning science through blended learning strategy. At first, the investigator outlined the sequence of questions to be asked during the interview. This written outline or the schedule provided a plan for the interview. Most of the questions were open ended. An open form question in which the subject is encouraged to answer in his or her own words at some length is likely to provide greater depth of response (Best & Kahn, 2009). The questions in the schedule were mainly based on the responses of students in the reaction scale which was intended to assess their reaction towards blended learning strategy. The interview was designed for about 20 minutes. The interview was conducted with four students to understand the comprehensibility and clarity of questions. Based on this, necessary modifications were made to the schedule.

3.4 DESIGN OF BLENDED LEARNING STRATEGY

A blended learning design suggested by Huang and Zhou (2005) was adapted for the present study. The procedure of designing blended learning strategy involves mainly three stages:

1. Pre-Analysis
2. Activity and Resource Design
3. Instructional assessment

1. Pre-Analysis Stage

Several observations and analyses were conducted in order to ascertain whether blended learning strategy could be used, and if so, to what extent online learning could be blended with face-to-face instruction. It mainly consisted of analysis of the science curriculum, environmental features of the school and students’ characteristics. Ninth standard science curriculum was analyzed to understand the scope for implementing the blended learning strategy. Environmental feature of the experimental school was analyzed through a preliminary visit to the school. Characteristics of ninth standard students including their views on online learning were collected and analyzed. The purpose of this task was to lay a sound foundation for organization of learning activities. Based on these analyses, an analysis report was prepared. Summary of the analysis is presented here.
• Ninth Standard students studying in the school in which www.thinkquest.org is available are familiar with the online learning platform and its facilities.
• The experimental school is equipped with facilities required for implementing blended learning strategy.
• Ninth Standard science curriculum has enough scope for implementing blended learning strategy.

2. Activity and Resource Design Stage

The unique feature of blended learning design is that it focuses on which activities and resources are appropriate for the online learning contexts and which activities are appropriate for the classroom contexts. This stage mainly consists of two sub stages-
   i. Overall design of blended learning
   ii. Design of activities and development/selection of resources and materials

i. Overall Design of Blended Learning

In this sub-stage, documents such as National Curriculum Framework 2005 published by NCERT and various documents published by UNESCO were reviewed to have better understanding on new perspectives in science teaching, especially in integration of technology in science teaching. In addition to this, experts and teachers were consulted to select topics for transacting through blended learning strategy. Out of fifteen units of science text book of ninth standard, six units were selected for the experimental intervention. This worked out to be 40% of the entire ninth standard science syllabus. Equal numbers of Physics, Chemistry and Biology units were considered for the experimental intervention.

The selected units were
   o Matter in Our Surroundings
   o Is Matter Around Us Pure
   o Force and Laws of Motion
   o Gravitation
   o Why Do We Fall Ill
   o Natural Resources
The content analysis of these units was carried out and the details are given in the following paragraph.

**Content Analysis:** The six units, which were identified for experimental intervention were analyzed specifying various concepts, meaning of those concepts, explanation with examples, and law/theorem. Content analysis helped the researcher to identify the major teaching points in the units, to sequentially arrange them to establish continuity in learning so that it helps in blending online learning with face-to-face instruction appropriately.

The major concepts covered in the units are given in the following table.

**Table 3.8: Major Concepts of the Selected Units**

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Units</th>
<th>Major Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Matter in Our Surroundings</td>
<td>Physical nature of matter, states of matter-solid, liquid, gas; diffusion of liquids, compressibility of gases, changes of state in matter, melting point, latent heat of fusion, boiling point, sublimation, evaporation</td>
</tr>
<tr>
<td>2</td>
<td>Is Matter Around Us Pure?</td>
<td>Mixture, Types of mixture, homogenous and heterogeneous, solution, concentration of solution, suspension, colloidal solution, separation techniques-evaporation, centrifugation, sublimation, chromatography, distillation, fractional distillation, crystallization, physical and chemical change, elements, compounds</td>
</tr>
<tr>
<td>3</td>
<td>Force and Laws of Motion</td>
<td>Force, balanced and unbalanced forces, First law of motion, inertia, momentum, Second law of motion, Third law of motion, conservation of momentum</td>
</tr>
<tr>
<td>4</td>
<td>Gravitation</td>
<td>Gravitational Force, importance of Universal law of Gravitation, free fall, acceleration due to gravity, variation of ‘g’ in different places, motion of objects under the influence of gravitational force, weight, thrust and pressure, pressure in fluids, Archimedes’ Principle</td>
</tr>
<tr>
<td>5</td>
<td>Why Do We Fall Ill?</td>
<td>Health and related personal and community issues, distinctions between ‘healthy’ and ‘disease free’, diseases and its causes, acute and chronic diseases, infectious and non-infectious diseases, prevention of diseases</td>
</tr>
<tr>
<td>6</td>
<td>Natural Resources</td>
<td>Resources on the earth, the role of atmosphere in maintaining climate, wind, rain, air pollution, water, water pollution, formation of soil, soil structure, soil pollution, water cycle, nitrogen cycle, carbon cycle</td>
</tr>
</tbody>
</table>
An illustration of the content analysis of a unit ‘Force and Laws of Motion’ is given in the Appendix-23.

After analyzing each unit thoroughly by specifying various concepts and their meanings, different resources and tools for transacting those concepts were identified and selected. The materials and the resources required for the blended learning strategy for each unit were identified and a comprehensive picture of the strategy was worked out.

Based on this overall design of blended learning units and the strategy, an overall design report for each unit was prepared specifying resources/tools supporting blended learning, skills to be developed and the mode of assessment. As an illustration, the overall design report for unit ‘Gravitation’ is given in the Appendix-24.

ii. Design of activities and development/selection of resources and materials

Suitable activities for transacting each topic were identified and objectives to be attained through each activity were formulated. The objectives were formulated based on all levels of cognitive, affective and psycho-motor domain. Activities were then sequentially arranged. The teaching-learning materials like write-ups and videos to be uploaded on the www.thinkquest.org web site, thought provoking questions to be asked to the students through message board and the demonstration/experiments to be carried out during the face-to-face instruction were designed. In addition to this, project descriptions to be uploaded on the online project page and the criteria for the evaluation of the project were prepared. Power Point presentations for transacting some topics were prepared whereas interactive educational CDs were selected for some other topics. The following guidelines were followed in the development of PowerPoint and for the selection of interactive educational CDs.

- Modules should be designed to promote growth in students’ level of intellectual sophistication and not solely to exercise skills or to provide simple association to content.
- Use of simple and error free language.
- Accurate, current and up-to-date information
- Appropriate for intended learners with respect to their age and language proficiency
• Clear and logically sequenced activities
• Scope for active involvement of learners
• Provisions for encouraging curiosity and wide ranging investigation by students

**Development of lesson plans:** The units selected for the intervention were examined carefully and lesson plans consisting of learning objectives, previous knowledge, learning activities, duration for each activity and evaluation were developed for all the six units. Lessons were planned keeping the general objectives of teaching science along with the objectives of teaching science through blended learning strategy. The number of lessons per unit varied from unit to unit according to the content and complexity of the unit. Both online and face-to-face instruction activities were detailed in the lesson plans. The lesson plan was prepared considering three steps namely, introduction, development and conclusion. As an illustration, lesson plan prepared for the lesson ‘gravitation’ from the unit ‘gravitation’ is given in the Appendix-25.

3. **Instructional Assessment Stage**

The final step in the design of blended learning strategy is the instructional assessment. Instructional assessment is based on the instructional objectives and the activities carried out. It is mainly the assessment of students’ worksheet, work done online by analyzing the articles published in students’ web page and by analyzing their online interaction with others, examination of content knowledge through tests, participation and interaction during face-to-face sessions etc. The design of blended learning strategy adopted for the present study is outlined below:
3.5 PROCEDURAL DETAILS OF THE STUDY

The present study was carried out in various stages. It includes pilot study and implementation which consists of administration of pretests, experimental intervention and administration of posttests, reaction scale and interview.

**Stage 1:**  
**Pilot study**

**Stage 2:**  
**Implementation**

- Administration of Pretests, Learning Style Inventory
- Experimental intervention
- Administration of Posttests, Reaction Scale, Interview
3.5.1 STAGE 1: Pilot Study

The tryout of the intervention was carried out in BGS National Public School, Bangalore for a period of two weeks. Topics from unit ‘motion’ were taught using blended learning strategy to ninth standard students and thinkquest.org (http://www.thinkquest.org) served as the platform for providing online learning. Students were familiar with the platform and the researcher provided necessary guidelines to be followed. The Face-to-Face (F2F) instruction included lecturing, demonstration, experimentation and computer assisted instruction. The piloting helped the researcher to get some hands-on experience in conducting science classes using blended learning strategy. It also helped to identify the extent of online learning to be provided along with face-to-face instruction.

3.5.2 STAGE 2: Implementation

Implementation phase consists of administration of pretests, learning style inventory, experimental intervention and administration of posttests, reaction scale and the semi-structured interview.

3.5.2.1 Administration of Pretests

The developed tests were administered as pretests to assess critical thinking, problem solving, science process skills and science achievement to both experimental group and control group. Each test was of 45 minutes duration and one test was conducted per day. Before administering the tests, the students were given necessary directions. The tests administered were scored and the scores obtained were considered as the pretest scores of the sample students.

3.5.2.2 Administration of Learning Style Inventory

Learning Style Inventory was administered to the experimental group students to identify their learning style such as visual, auditory and kinesthetic. Students were given 20 minutes for completing the learning style inventory. The inventory was scored and the learning style of students was determined by estimating the number of preferences under each category. The category in which a student scored the maximum was regarded as the dominant learning style of that student.
3.5.2.3 Experimental Intervention

The intervention was carried out for 69 periods of 45 minutes each, extending 20 weeks approximately. The time allocation for different types of teaching methods is given below.

Table 3.9: Time Allocation for Teaching-Learning Processes

<table>
<thead>
<tr>
<th>Teaching-Learning Processes</th>
<th>Number of periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiments</td>
<td>12</td>
</tr>
<tr>
<td>Project (Discussion, monitoring and feedback)</td>
<td>7</td>
</tr>
<tr>
<td>Lecture-cum-Demonstration</td>
<td>13</td>
</tr>
<tr>
<td>Computer Assisted Instruction</td>
<td>11</td>
</tr>
<tr>
<td>Lecturing</td>
<td>6</td>
</tr>
<tr>
<td>Online Learning</td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>69</strong></td>
</tr>
</tbody>
</table>

The experimental group was taught the selected units of science using blended learning strategy by the researcher. The lesson plans designed served as the basis for blending Face-to-Face (F2F) instruction and online learning for the transaction. Face-to-face instruction included lecturing, discussion, demonstration and experimentation along with the computer assisted instruction using CD-ROM. Online learning was facilitated via web based online learning platform ‘www.thinkquest.org’ using facilities of publishing articles on web page, message board, list, uploading pictures, video and online collaborative projects.

The discussion of online activities continued in the classroom with the guidance of the researcher. Activities done and discussions carried out in the classroom were continued through the online learning platform. In addition to this, the developed teaching learning materials like PowerPoint presentations which were used in the classroom were made available to the students through the online learning platform for better learning and understanding. Attempts were made to ensure students’ participation during the instruction by encouraging them to discuss on core issues presented.

Students’ interactions among themselves and with the researcher were ensured through classroom discussions as well as through activities done online. The experiments and demonstrations carried out in the classrooms provided hands on experience to students whereas the videos of the experiments uploaded on the online
learning platform were aimed at providing better understanding of the concepts discussed and to promote self regulated learning.

3.5.2.4 www.thinkquest.org as a platform for Online Learning

Thinkquest is a web based collaborative learning platform, which provides online learning tools with the powerful Internet components. It is a password protected, global online learning platform which connects schools, teachers and students all over the globe. The mission of thinkquest is to inspire students globally to connect, create and share-using technology to help them dissolve boundaries, fulfill their potentialities and create a better society. The scope of thinkquest varies from sticking messages to creating an innovative project based learning activity. Each student and teacher is allowed to create their own web page on the platform in which they can publish different articles. In addition to this, all members of thinkquest are permitted to interact with all the other members using the online collaborative learning tools such as message boards, brainstorming tool, vote tool, ask-me corner, debate forum etc.

3.5.2.5 Treatment

The researcher was provided with access to thinkquest by providing a user name and a password by the principal of the experimental school. After logging into the web site ‘www.thinkquest.org’, the investigator created her own web pages through which online activities could be undertaken. As the discussion progressed in the classroom, various articles were published on the researcher’s web page using the provision of ‘write’. In addition to this, various write ups on topics like gravitation, natural resources, matter etc were uploaded as the content progressed in the face-to-face instruction. The PowerPoint presentations used in the classroom and other relevant video clips were also uploaded using the provision ‘upload’.

The researcher used the facility of interacting with students through message board and it helped the researcher to give timely feedback to the students. Online threaded discussions on various curricular issues were conducted. Meanwhile, lecturing, demonstrations and experiments were undertaken in the classroom as the content demanded. The materials posted online, online discussions etc were performed hand-in-hand with the classroom activities. The discussion in the classroom was continued in the discussion forum using message board and visa-versa.
Students were asked to publish various write-ups on their own web page by referring the various websites prescribed by the researcher and referring online library materials available in thinkquest. Further discussion on the topics was continued during the face-to-face instruction. Students interacted with other members of the online platform, which included both teachers from their own school as well as students and teachers of different schools and countries by using the facilities such as message, ask me, list, vote etc. The feedbacks and varied perspectives students gained through thinkquest were further expanded upon by the researcher during face-to-face sessions.

The below given snapshot illustrates one of the files uploaded by the researcher regarding the learning unit - ‘matter’ on her thinkquest.org webpage. An initial discussion was conducted on ‘matter’ and experiments were performed to have a better understanding on the properties of matter during the face-to-face instruction followed by a PowerPoint presentation. The PowerPoint used in the classroom was uploaded on the researcher’s web page.

Figure 3.2: Snapshot of webpage showing files uploaded by the researcher on the unit – ‘matter’

The activities done in the classroom were followed by online activities done by students. Students were given necessary guidelines and information by the researcher through her web page on thinkquest. In addition to uploading files or write-ups, different web links were provided by the researcher on various topics for
encouraging students to understand the topics more clearly as well as to help self learning.

The following snapshots illustrate the web links provided by the researcher on ‘Archimedes’ Principle’. Students were asked to go through the web links provided on the researcher’s web page and further discussion was carried out in the classroom by elaborating students’ ideas. This was followed by an experiment conducted in the lab. Students performed experiments in groups to get hands on experience on Archimedes’ Principle. The applications of Archimedes’ Principle were again discussed in the classroom and video of experiment on Archimedes’ Principle was uploaded on the web page of the researcher. The video provided through the online learning platform helped the students to revise the procedure of the experiment and thus helped in reinforcing the learning.

Figure 3.3: Snapshot of webpage showing weblinks provided by the researcher on the topic – ‘Archimedes’ principle’

Based on the guidelines provided by the researcher, students created their own web pages and published write ups on various topics. For example, after being given explanation on ‘gravitation’ during face-to-face instruction, students were asked to go through the web page created by the researcher and were asked to prepare their own write ups on gravitation. Students went through the web pages of their classmates and gave feedback. Necessary feedback was provided to the students by the researcher and the discussion on the topics continued during the face-to-face instruction.
The following snapshots provide the online articles prepared by students on ‘gravitation’.

Figure 3.4: Snapshot of a student’s webpage illustrating an article published online

Figure 3.5: Snapshot of a student’s webpage illustrating an article published online
The researcher interacted with the students through the online learning platform by making use of the provision ‘message board’ by asking questions and by encouraging students to comment on various issues forwarded through her web page. The following snapshots show the interaction of students with the researcher through the online forum and other webpages on topics such as ‘buoyancy’, ‘pollution’, and ‘gravitation’.

Figure 3.6: Snapshot of a student’s webpage illustrating an article published online

Figure 3.7: Snapshot of a student’s webpage illustrating an article published online
(‘Mrs. Monika’ in the snapshot below is the account provided to the researcher by the principal of the school.)

**Figure 3.8:** Snapshot showing the interactions of students with the researcher through the online forum on ‘Buoyancy’

![Image of Figure 3.8]

**Figure 3.9:** Snapshot showing the interactions of students with the researcher through the online forum on ‘Buoyancy’

![Image of Figure 3.9]
Figure 3.10: Snapshot showing the interactions of students with the researcher through the online forum on ‘Buoyancy’

Figure 3.11: Snapshot showing the interactions of the researcher with the students through her webpage
Moreover, students could interact with their classmates or students and teachers of other schools on various topics. The following snapshots illustrate the interaction among students through the online forum on different topics.

Figure 3.12: Snapshot showing students’ interactions with the researcher through the online forum on various topics

Figure 3.13: Snapshot showing interactions among students through the online forum
Online collaborative projects were carried out with maximum participation and collaboration among students. The following paragraph illustrates the online project carried out on the topic ‘Pollution’ taken from the unit ‘Natural Resources’.

The researcher created web page for the online project and initiated the activities by publishing background information about the project including a title, essential questions, application and expected outcome of the project. The researcher titled the project: ‘Pollution – A Global Threat or Local Reality’. Students were added to the project as members and were divided into three groups—the first group on air pollution, the second group on water pollution and the third group on soil pollution. The guidelines to be followed and the date of completion of the project were mentioned on the project web page. The project evaluation criteria prepared by the researcher was uploaded on the project page so that students could design the project appropriately. During the face-to-face instruction, the researcher explained the scope of the project and the various activities to be carried out. Students discussed in their respective groups and the doubts were clarified in the classroom as well as online. Continuous monitoring was done and timely feedback was provided to the students.

Along with the online activities using different options like write, list, message board and upload, students collected data by conducting surveys in their locality to understand the real causes of pollution and awareness of people towards it. Students
even interacted with students and teachers of other countries through online forums which helped them to understand the causes and effects of pollution in different geographies. They also interacted with people in their own locality to understand the ill effects of pollution as well as the measures taken by people to minimize the ill effects of pollution. After the compilation and interpretation of data, a comprehensive project report was published on the thinkquest website. The presentation by each group was carried out in the classroom accompanied by different charts, models and a collage. Students prepared small skits on the issue and presented in front of the whole class and videos of the skit were uploaded on the website. Further discussion was carried out in the classroom after the presentation. At each stage of the project, monitoring was done and feedback was given to students. In this way, the blended learning strategy was implemented to the experimental group incorporating various resources both through online and face-to-face.

The following snapshots provide an illustration of the online projects done by students.

**Figure 3.15: Snapshot of the webpage of an online project done by the students on the topic of ‘Pollution’**
Figure 3.16: Snapshot of the webpage of an online project done by the students on the topic of ‘Pollution’

Figure 3.17: Snapshot of the webpage of an online project done by the students on the topic of ‘Pollution’
Figure 3.18: Snapshot of the webpage of an online project done by the students on the topic of ‘Pollution’

Figure 3.19: Snapshot of the webpage of an online project done by the students on the topic of ‘Pollution’
3.5.2.6 Conventional method of teaching as observed during visits to the control group

During the intervention period, the researcher visited the control group and observed science classes taken by the regular teacher. The science teacher of the control group was consulted and found that the duration taken for teaching the
selected units in the control group was approximately the same as that of the experimental group. Science classes were conducted by using conventional teaching method and were completely devoid of any kind of online learning. The control group visit revealed that topics were being taught through demonstration and lecturing, followed by answering questions from students. The interaction with the teacher and among students was limited and the bright students were answering questions whereas other students were mostly passive in the class. The interaction of researcher with students of the control group revealed that experiments held were conducted in an isolated manner in the lab and they were not a continuation of the lectures/discussions held in the class.

Below is the sequence of events that took place while teaching ‘Archimedes’ Principle’ using blended learning strategy (transacted by the researcher) and conventional method of teaching (taught by the regular teacher as observed by the researcher during control group visits).

**Blended Learning Strategy**

- Initiation of the lesson by asking students about their day to day life experiences of ‘floatation’
- Students’ group activity shows upward force of water; discussion in groups and presentation of the observations by each group
- Researcher’s explanation on ‘buoyancy’
- Group Activity-Students classify the objects which float on water and objects which sink in water and further discussions conducted in the classroom
- Researchers’ web page uploaded with web links and video on ‘buoyancy’ and students asked to find out answers for the questions given at the end of the video
- Online threaded discussion on floatation of ‘ice’ initiated by the researcher
- Further discussion in the classroom on floatation of ice and researcher’s explanation
- Experiment on ‘Archimedes’ principle’ in the science lab and discussion on its applications
- Video on ‘Archimedes’ Principle’ are uploaded on researcher’s web page
- Publication of write ups on ‘buoyancy’ in the online forum by students
- Feedback to students’ write up on ‘buoyancy’ through the online forum
Conventional Method of Teaching

- Initiation of the topic by asking day to day life experiences related to the topic
- Teacher’s explanation on ‘buoyancy’ and students asked to write down its definition
- Demonstration by the teacher on ‘floatation’
- Teacher asks explanation from students; teacher was not satisfied with the answers given and asks “can any one give ‘the correct answer’ ’’?
- Explanation by the teacher and students were asked to write down the reason for floatation in the note book
- Students were asked to give reason for the decrease in elongation of the string as the stone attached to the string is immersed in water
- One of the active boys in the class (who raises hands for every question) gives the proper explanation and teacher agrees to that response and repeats the same
- Teacher elicits application for ‘Archimedes’ Principle’

The discussion with the students of the control group in the last phase revealed that the experiment on ‘Archimedes’ Principle’ was carried out later, not as a sequential activity while teaching the topic. The experiment was conducted as it was one of the experiments which was to be performed as per the syllabus.

3.5.2.7 Administration of Posttests, Reaction Scale and Semi-Structured Interview

Immediately after the intervention, posttests on critical thinking, problem solving, science achievement and science process skills were administered to the experimental group and control group. The atmosphere in which the posttests were conducted was same as that of the pretests. Reaction scale was administered to the experimental group. Semi-structured interview was conducted to 16 randomly selected students of the experimental group to find the difficulties faced by them in learning science through blended learning strategy. The time taken for semi-structured interview for each student was about 15-20 minutes.

3.5.3 Scoring

Critical thinking test, problem solving test, science process skill test and science achievement test were scored. The scoring keys given in the appendices 11,
12, 13 and 14 were used for scoring the responses of students. In all the tests, one mark was given for the correct response and zero for the wrong response. Total marks obtained by each student in each of the tests were calculated. In the learning style inventory, one mark was given to preference in each category and the total score in each group - Visual, Auditory and Kinesthetic was calculated for each student and the maximum scored category was decided to be the dominant learning style of the student. The responses in the reaction scale was scored by giving weightages 3 to 1 for ‘totally true’ to ‘not at all true’. The total score of all the items in the reaction scale was calculated.

3.6 CONCLUSION

The present chapter discussed the details pertaining to methodology of the study including sampling, preparation of tools and procedural details of the study. The next chapter deals with the analysis of the data collected and its interpretation.