CHAPTER III

METHODOLOGY

3.0.0. INTRODUCTION

After the formulation of objectives, hypotheses, and a review of related literature, the next and third steps are to plan the procedures of the study. It is the most important phase of the study and ensures a fair, reliable, valid and objective way of carrying out research. The present study is experimental in nature, and the methodology of experimental research has been followed to fulfil the goals of the current study. The present chapter describes each step of methodology in detail, with major headings like research design, population, sample, tools of data collection, development of strategies, the procedure of data collection, and the procedure of data analysis.

3.1.0. RESEARCH DESIGN

The present study was experimental in nature, and the researcher used a quasi-experimental research design. A pre-test and post-test non-equivalent group design of the quasi-experiment research design was selected for the study. Further, the experimental and control groups were made equivalent on the basis of pre-test scores in scientific temper. The design of the study is presented as follows (Campbell & Stanley, 1966).

O_1 X O_2

.....

O_3 C O_4

Where O_1 and O_3, are pretest (Scientific Temper)

O_2 and O_4 are be post-test (Scientific Temper)

X stands for experimental group and

C stands for control group

Following the said design, two groups were selected conveniently as experimental and control groups. The initial level of scientific temper had been checked prior to the experimentation by using a scientific temper scale prepared by the researcher. On the basis of the obtained score on the scale, the experimental and control groups were made equivalent. The treatment, i.e., teaching through developed strategies to enhance scientific temper, was done in the experimental group while the control group was taught through the traditional method without applying any kind of specific interventions.

3.2.0. POPULATION

The population for the present study is composed of all the students of the English-medium secondary schools in Gujarat state affiliated to GSHSEB (Gujarat Secondary and Higher Secondary Education Board) during the year 2019–20.

3.3.0. SAMPLE

Two English-medium GSHSEB affiliated secondary schools were selected by using a non-probabilistic sampling method, i.e., convenient sampling from Vadodara district for the experimentation during the academic year 2019-2020. Both the selected schools were equal in standards and located in the city area only. The names of the two schools are University Experimental English Medium School and Vidyakunj High School. Out of these two schools, the former one was selected for the experimental group and the latter one was selected for the control group. The Standard IX classes from both the selected schools having more than 45 students formed the sampling frame for the present study. Both groups were made equivalent on the basis of pre-test scores on the scientific temper scale. In this way, a total of 64 students, 32 from the experimental and 32 from the control group, formed the sample of the study. Students of the experimental group were taught through developed strategies, while the students of the control group were taught through the usual traditional method. The summary of the sample distribution is shown in table 3.1.

Table 3.1: Sample distribution for Experimental and Control Groups

Group	Number of Students
Experimental group	32
Control group	32
Total	**64**

3.4.0. VARIABLES OF THE STUDY

Following variables were considered in the present study.

Independent Variable: The independent variables are the conditions or characteristics that the experimenter manipulates or controls in his or her attempt to ascertain their relationship to observed phenomena (Best & Kahn, 2006). In the present study, the developed strategy for enhancing Scientific temper was considered as independent variable.

Dependent Variables : The dependent variables are the conditions or characteristics that appear, disappear, or change as the experimenter introduces, removes, or changes independent variables (Best and Kahn, 2006). It is also known as response variable. In the present study, Scientific temper and reaction of students towards the developed strategy were considered as the dependent variables.

3.5.0. TOOLS FOR DATA COLLECTION

A tool is the most important aspect of the research as it provides the means to collect the data from the respondents. It ascertains the accuracy of the data along with the conclusion about the problem at hand. Hence, it is the major task of the researcher to select or prepare the right tools to measure the variables in the undertaken study. In the present study, researchers have taken two tools, which are as follows.

1. Scientific Temper Scale and
2. Reaction Scale

Both the tools were constructed by the researcher. The details of the said tools are mentioned as follow.

Scientific temper scale: The scientific temper scale was developed and standardised by the researcher meant for the secondary school students and is given in Appendix I. The detail of the various procedures involved in the development and standardisation of the tool is described in detail.

Reaction scale: The researcher has prepared a five-point Likert type scale to know the reaction of students towards the developed strategies to enhance scientific temper. There was total 30 statements in the scale related to different aspect of their experiences during the execution of strategies and teaching learning. Each statement has five-point ratings viz. strongly agreed to strongly disagreed. The weightage for ratings of the scale are 5,4,3,2,1 respectively for the SA, A, UD, D, SD. In this way the highest score one could get was 150 and lowest was 30. The students were asked to read each statement carefully and mark a tick on a suitable option for each statement. The scale was validated by the experts. There was no time limit to complete this scale. The reaction scale towards developed strategies to enhance scientific temper is given in Appendix III.

3.6.0. DEVELOPMENT AND STANDADISATION OF SCIENTIFIC TEMPER SCALE

For the purpose of measuring scientific temper the researcher has decided to construct a scale having five degrees of measurement from 1 to 5 for each item. Following steps were followed to prepare the scale:

Identification of components of scientific temper: The first step in the development of a tool is to identify the components or area which needs to be covered under a tool. For this purpose, the researcher has identified total eight components of scientific temper after a thorough study of the topics and analysing the review of related literature. The components are listed in Table 3.2 with the descriptive behavioural terms.

Table 3.2: Components selected for the Scientific Temper Scale along with their behavioural terms

Components	Description/Operationalization
Healthy Scepticism	• One does not accept others' assertions unless those are logical, rational and supported by proper evidence • One sees everything with the critical mind set • One believes in redoing the experiments by own self and determine whether the evidence is trustworthy • One questions everything for its trustworthiness
Objective Intellectual Honesty	• One judges fairly, without partiality or external influence by considering all pros and cons • One does not purposefully omit the relevant facts and information even when it contradicts one's own hypothesis • One does not allow any modifications according to present social, economic or political situations • One's faith does not interfere with one’s pursuit of truth
Rationality	• One tends to test traditional beliefs • One accepts the criticism whole heartedly • One follows the systematic and logical way of finding a solution to the problem. • One removes all emotional components from the decision-making process and focus solely on facts
Perseverance	• One does not believe in giving up things if there is a scope to complete it • One pays attention to what's possible, which includes realizing when to withdraw, let go or surrender • One feel motivated to move forward with the plans even when it seems that it might not be successful

	• One's Persistence and tenacity to do something and keep doing it till the end, even if it's hard
freedom from superstition	• One rejects the superstitions and false beliefs • One believes in cause and effect relationship • One does not believe in good or bad luck • One does not believe in magic or supernatural events
Curiosity	• One's desire for understanding new things that are not explained • One's desire for completeness of knowledge • One asks a lot of questions to seek answers • One listens to things very carefully
Open Mindedness	• One's willingness to revise opinion and conclusions • One's approach towards all the things without pride and prejudices • One rejects the singular and rigid approach to people, things and ideas. • One recognises that there may be better ideas
Observation	• One tries to identify differences between similar objects or events • One tries to identify similarities between different objects or event • One is attentive in observing things • One notices the odd one out

Item Writing: After listing the components and operationalising those, the next step was to formulate the items in the line of selected components. Age and grade of students, their school and home environment, length of scale, comprehensibility, time needed to complete etc. had been taken into consideration while forming the items for scale. The scale was prepared in English. In the initial pool, a total of 80 items were formed, 10 items in each component. Each item was based on a situation having five probable responses, ranging from 1 to 5 indicating different levels of scientific temper. These items were then shortlisted to 50 items after a long deliberation and discussion with the guide. The tool with these 50 items was given to the experts for validation in terms of the content and language appropriateness. On the basis of the suggestions from the experts the items were modified and reduced to 40. In this way, the preliminary draft of the scientific temper scale contained 40 items, 5 in each sub component.

First Tryout: The modified tool with the corrected items were then administered in a sample of 10 students of standard IX to know the language appropriateness, and comprehensibility. On the basis of the first tryout few modification was done on the tool.

Second Tryout: Second try out was done with 45 students of standard IX. The intercorrelation of each item with the total score was found out by taking out with the help of product moment correlation. The significance level of the calculated coefficient of correlation was checked at the 0.05 level of significance. The items with low coefficient of correlation were discarded from the scale. Hence, a total of 32 items remained in the scientific temper scale thus having 4 items in each sub components. The detailed description of this process in given in table 3.3.

Table 3.3: Correlation of each item with the total score at 0.05 level of significance

Items No.	Correlation value	Level of significance	Selection
Item 1	0.41	Significant	Selected
Item 2	0.28	Significant	Not Selected
Item 3	0.34	Significant	Selected
Item 4	0.32	Significant	Selected
Item 5	0.36	Significant	Selected
Item 6	0.32	Significant	Selected
Item 7	0.29	Significant	Selected
Item 8	0.33	Significant	Selected
Item 9	0.44	Significant	Selected
Item 10	0.23	Significant	Not Selected
Item 11	0.29	Significant	Selected
Item 12	0.28	Significant	Selected
Item 13	0.31	Significant	Selected
Item 14	0.38	Significant	Selected
Item 15	0.22	Significant	Not Selected
Item 16	0.40	Significant	Selected
Item 17	0.34	Significant	Selected
Item 18	0.35	Significant	Selected
Item 19	0.37	Significant	Selected
Item 20	0.10	Not Significant	Not Selected
Item 21	0.41	Significant	Selected

Item 22	0.22	Significant	Not Selected
Item 23	0.49	Significant	Selected
Item 24	0.34	Significant	Selected
Item 25	0.43	Significant	Selected
Item 26	0.30	Significant	Selected
Item 27	0.32	Significant	Selected
Item 28	0.34	Significant	Selected
Item 29	0.16	Not Significant	Not Selected
Item 30	0.31	Significant	Selected
Item 31	0.28	Significant	Not Selected
Item 32	0.35	Significant	Selected
Item 33	0.42	Significant	Selected
Item 34	0.42	Significant	Selected
Item 35	0.54	Significant	Selected
Item 36	0.32	Significant	Selected
Item 37	0.36	Significant	Selected
Item 38	0.35	Significant	Selected
Item 39	0.25	Significant	Not Selected
Item 40	0.41	Significant	Selected

Final Draft: The final draft with 32 items was administered on 204 students of Standard IX for finding the validity and reliability.

Validity: The content and factor validity of the scientific temper scale was found our which are given as follow.

Content Validity: The content validity of the scientific temper scale was found for the language and content appropriateness. This was done by the experts from the field of Education, Psychology and school education. The final prepared scale was given to 10 experts in the related field for the validation of the scale. The suggestions were received from the experts in terms of length of tool, use of words in some items, and modification in certain items. All the given suggestions were incorporated in the scale to ascertain its validity.

Factor Validity: To establish the factorial validity of the scientific temper scale the inter-correlation between the total score and the 8 components were found out. For this purpose, a 9 x 9 metrics was prepared to find out the inter-component correlations. The results showed positive and significant inter-correlations among all the components which is shown in table 3.4. It indicates that the scale has high factorial validity.

Table 3.4: Inter-correlation of total score with 8 components of Scientific Temper Scale

	HS	OIH	R	P	FFS	C	OM	O	Total
HS	1	.336**	.219**	.240**	.324**	.209**	.291**	.205**	.576**
OIH		1	.251**	.333**	.216**	.233**	.310**	.215**	.604**
R			1	.278**	.382**	.240**	.199**	.132	.559**
P				1	.288**	.267**	.261**	.275**	.598**
FFS					1	.258**	.335**	.317**	.668**
C						1	.185**	.311**	.540**
OM							1	.355**	.634**
O								1	.604**
Total									1

HS: Healthy Scepticism, OIH: objective intellectual honesty, R: Rationality, P: Perseverance, FFS: freedom from superstition, C: Curiosity, OM: Open Mindedness, O: Observation, ** Significant at 0.05 level

Reliability: The reliability of scientific temper scale was found out by using Split half and Cronbach Alpha methods separately. The coefficients of correlation for Split half method and Cronbach alpha method were found to be 0.75 and 0.79 respectively. On the basis of these reliability coefficients, the reliability of the scientific temper scale could be considered as high.

The scientific temper scale had 32 items. All the items in the scale have been arranged in the sequential order with eight components viz. healthy scepticism, objective intellectual honesty, rationality, perseverance, freedom from superstition, curiosity, open mindedness, observation

from 1 to 32 having four items in each component respectively. Each items having response ranging from 1 to 5. The response which shows the highest level of scientific temper was assigned the value of 5 while the lowest level represented with 1. In this way the minimum and maximum score in the scientific temper scale varies from 32 and 160. The detail of scoring procedure of each item of the scientific temper scale has been given in the table 3.5.

Table 3.5: Item wise Detailed Scoring Procedure of the Scientific Temper Scale

Item No.	Scoring				
	a	b	c	d	e
1,5,9,13	3	2	4	1	5
2,6,10,14	2	4	1	5	3
3,7,11,15	3	1	2	5	4
4,8,12,16	4	3	1	5	2
17,21,25,29	5	2	1	3	4
18,22,26,30	1	5	3	2	4
19,23,27,31	2	5	3	4	1
20,24,28,32	4	2	1	5	3

The format of booklet and scoring sheet is attached in Appendix I and II respectively.

3.7.0. DEVELOPMENT OF STRATEGIES

In the present study, strategies were developed by the researcher to enhance the scientific temper among secondary school students by teaching Science, Mathematics and Social Science subjects in the following steps.

3.7.1. Step 1: Identification of chapters in Mathematics, Science and Social Science Subjects

The study is based on GSHSEB syllabus. Hence the identification of chapters were done from the GSHSEB prescribed books on the basis of common chapters taught in both the experiment and control group schools in second semester which was started from October, 2019. Among the selected three subjects the syllabus of Mathematics and Science subject were same as both the schools were following NCERT books. In case of Social Science GSHSEB prescribed book was used in both the schools. In all these three subjects' same chapters were taken which were

taught in both the schools during the second semester. The researcher has taken 6-7 chapters from each subject as per the convenience and availability of time. Subject wise chapters shown in Table 3.6.

3.7.2. Step 2: Content Analysis and Scientific temper component identification

Once the identification of chapters was done, the researcher in the next step had gone through each chapter and identified the components of scientific temper those can be developed with the help of those chapters. For this purpose, the researcher had divided the chapters into various topic and subtopics so that all the identified scientific temper components can be included. The teachers of these three subjects were teaching the respective topics along with the researcher. The teachers were teaching the components of their respective subjects where there is no scope for developing scientific temper whereas the researcher was teaching all the components of all the three subjects having scope for developing scientific temper. The details of the subtopic taught by the researcher having scope for developing scientific temper is given in table 3.6 including the strategies used for this purpose.

Table 3.6: Subject-wise and chapter-wise distribution of sub topics having scope for developing Scientific Temper (ST) along with the strategies used

Chapter No.	Chapters	Sub Topic	ST Components	Strategies used
Science				
3	Atoms and Molecules	Law of Chemical Combustion, Atom Size, Symbols, Atomic Mass Molecules and Ions	OIH, FFS OM, O	ICT Enabled Learning (Video, PPT, Image) Questioning Discussion Worksheet
4	Structure of Atom	Different Models of Atom	P O	ICT Enabled Learning (Video, PPT) Questioning Discussion
7	Diversity in Living Organism	Basis of classification	OM P FFS	ICT Enabled Learning (Video, PPT)

		Identifying local flora and fauna		Story Telling Questioning Discussion
11	Work and Energy	Work and its types Energy and its Forms	HS R C	ICT Enabled Learning (Video, PPT) Questioning Discussion
12	Sound	Production and propagation of sound Use of reflection of sound Working of ear	OIH R FFS	ICT Enabled Learning (Video, PPT) Story telling Questioning Discussion News analysis
14	Natural Resources	Air pollution and its effect	R O C	ICT Enabled Learning (Video, PPT) Movie analysis Questioning Discussion
15	Improvement in Food Resources	Improvement in cropping yield	HS P FFS	ICT Enabled Learning (Video, PPT) Story Telling Questioning Discussion
Mathematics				
8	Quadrilaterals	Concept of Quadrilaterals	HS R P	ICT Enabled Learning (Video, PPT) Worksheet

		Types and Properties of Quadrilaterals		Questioning Discussion
9	Area of Parallelogram and Triangles	Identifying Figures on same base and between the same parallels	C FFS O	ICT Enabled Learning (Video, PPT) Story telling Questioning Discussion
10	Circles	Circle and related terms: A review	OM P O	ICT Enabled Learning (Video, PPT) Questioning Discussion
11	Construction	Basic Constructions	OIH C O	ICT Enabled Learning (Video, PPT) Story telling Questioning Discussion Worksheet
12	Heron's Formula	Introduction of Heron's formula	OIH OM C	ICT Enabled Learning (Video, PPT) Questioning Discussion
14	Statistics	Collection and types of data Measure of central tendency	HS FFS O	ICT Enabled Learning (Video, PPT) News analysis Questioning Discussion
Social Science				

5	Movement towards Independence	Indian struggle movement (1920-1947) Dandi March and Azad hind Fauj and Subhash Chandra Bose	OM R P O	ICT Enabled Learning (Video, PPT) Story telling Questioning Discussion Time line making News analysis
6	World war after 1945	Cold war reasons and consequences	HS R O	ICT Enabled Learning (Video, PPT) Story telling Discussion Questioning INews analysis Debate
11	Indian Judiciary	Judiciary and its Importance	OIH R O	ICT Enabled Learning (Video, PPT) News analysis Discussion
12	Indian Democracy	Election in Democracy Role of media in Democracy	OIH OM R	ICT Enabled Learning (Video, PPT) Story telling Role play Questioning
16	Climate	Factors affecting Climate & Climate and Human life	HS R FFS	ICT Enabled Learning (Video, PPT) Discussion News and movie Analysis Drawing

18	Wild Life	Dangers to Wild Life	HS P FFS	ICT Enabled Learning (Video, PPT) News and movie Analysis Discussion
19	Indian Human life style	Life style of North, South East and West India	OM C O	ICT Enabled Learning (Video, PPT) Worksheet Discussion

HS: Healthy Scepticism, OIH: Objective Intellectual Honesty, R: Rationality, P: Perseverance, FFS: Freedom from Superstition, C: Curiosity, OM: Open Mindedness, O: Observation

3.7.3. Step 3: Strategies used for the development of scientific temper

After the selection of topics and assignment of scientific temper components to it, the researcher had developed the strategies to use during the teaching learning process. The strategies were implemented in an integrated manne. As we all know schools have very restricted time to finish the syllabus along with all the co-curricular activities, the researcher had taken the integrated approach so that in real setting it can be feasible to implement. The strategies used are ICT enabled learning, story telling, questioning, timeline, debate, discussion, role play, news/movie analysis, drawing, and worksheet. Detail of each of these strategies are given below.

ICT (Information Communications Technology) enabled learning: Use of ICT catches the attention of students and make them an active learner hence for the explanation of all the selected topics and sub topics ICT was used. Some of the ways where ICT was used were videos (in the form of stories, movies and normal presentation), showing power point presentation, timeline, image and news showcasing, showing plant-net app. Some of the readymade available media were also downloaded from internet from the open sources by keeping the creative common licence in mind. This was used to develop all components of scientific temper and make other strategies more powerful.

Story telling: Stories are great strategy to inspire students. Here stories are used mainly to develop perseverance component of scientific temper where students were shown the stories

like Gandhiji's Dandi march and struggle of Subhash Chandra Bose in social science, story of Shrinivas Ramanujan in mathematics subject, where he was compelled to prove his axioms by Hardy and he pushed his limit to do that, and the story of Neil Harbisson in science subject who has invented a device through which he can listen colours through its reflected frequency in science subject. Besides these main stories many small incidents were also included through small stories.

Questioning: This strategy is the most ancient form of teaching learning which holds a great value even in the present context. Hence, questioning strategy was used to challenge the scientific thinking of students. It was used during the explanation as well as at the end of the class and taken as a tool to develop healthy scepticism, rationality, curiosity component of scientific temper.

Timeline: This strategy is most useful to reflect back what is learnt in one go and serve as a great tool for observation and consolidation. Hence, it was used in the subject of social science to see the timeline of different events took place in history. It was used at the end of the class in the form of activities which helped in the development of observation component of scientific temper.

Debate: This strategy is one of the best way to put forward different views of the students, to make them think in the divergent manner and to understand others views. This results in the development of open mindedness and objective intellectual honesty component of scientific temper. In the present study, students were informed about the debate beforehand taking some topics for making preparation of the same. It helped them to know both for and against side of the different topics. To ensure the maximum participation of students in this activity it was followed by intensive discussion on the question which arose during the debate.

Discussion: Discussion is a most powerful strategy for clearing the misconception during the learning process. This is the reason that this strategy was used in almost all the topic taught so that the concept clarity can occur. This is the strategy which can be used to develop all components of scientific temper. This strategy was also used as a supporting strategy in all other strategies used.

Role play: It is the best strategy to see things from others perspective. For which this strategy was used in the subject of social science. For example, while teaching the chapter democracy two students played the role of lenders and rest were voters. Leaders were asked to pursued the voters and the voters performed the duty of voting through ballot system. This strategy helps in the development of rationality component of scientific temper.

News/movie analysis: Students should be given enough opportunity to analyse the things happening around the world. For this purpose, the researcher had used news and movie analysis strategy in teaching. In this strategy the news like solar eclipse, historical old news related to freedom struggle etc. were shown and told them to analyse and put forward their views. Likewise for the movie analysis, the movie clip of "Man" created by Steve Cutts were shown that contains the harmful activities of human being towards the nature. At the end of movie, they were told to analyse the movie in different dimension by questioning and discussion. It helped in the development of freedom from superstition and observation component of scientific temper.

Drawing: This strategy was used for the free expression of ideas and views among the respondents. It was used as an individual activity where students presented their views in the form of drawing. It helped in the development of observation component of scientific temper.

Worksheet: This strategy was used as a group activity for the presenting their views. This was done to bring them together and show them the same thing with different angles. This strategy helped in the development of objective intellectual honesty, open mindedness, and rationality component of scientific temper.

While using these strategies the following points were kept in mind.

- All the preparation was done beforehand to reduce the wastage of time in settings like audio and video while using ICT enabled class.
- All the content delivery was done by using ICT so that the time can be saved for the hands on activities.
- The maximum length of the video or movie shown were less than 5 minutes catering the attention span of the students.

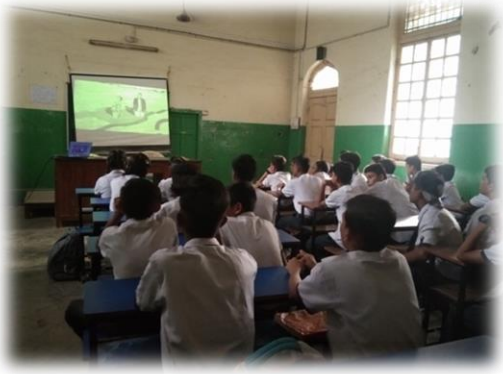
- The teaching was done in a pattern of 2-8-5-10-5 where 2 minutes for introduction, 8 minutes for explanation, 5 minutes for questioning and other kind of doubts, 10 minutes for activities like movie/news analysis etc. and last 5 minutes were used for the evaluation.
- Most of the activities were group oriented so that students can develop the skill of collaboration and seeing things from different point of views. It helped in the development of open mindedness, rationality and objective intellectual honesty in them.

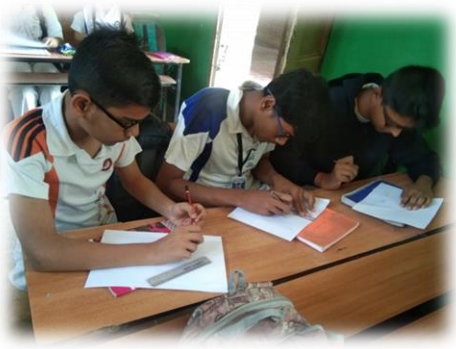
3.7.4. Step 4: Preparation of Lesson Plan

Considering the discussed components, the researcher has prepared the lesson plan of all the selected subjects using Herbatian steps. The sample lesson plan of three subjects are attached in APPENDIX IV, V and VI.

3.8.0. IMPLEMENTATION OF DEVELOPED STRATEGY

The developed strategies were implemented in the experimental group for the teaching of Science, Mathematics and Social Science subjects with the chapters common in both experimental and control group. The selected topics those could develop scientific temper in all the subject were taught by the researcher in the allotted classes that varies 3-5 classes in a week. This activity was continued for the whole second semester. Photographs of implemented strategies are presented below.





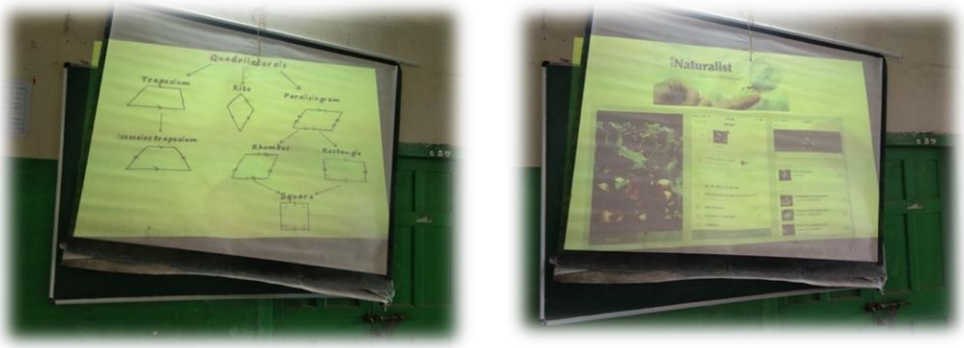


Figure 3.1: Photographs of Implemented strategies

Photographs of the experiment are attached in APPENDIX VII.

3.9.0. DATA COLLECTION PROCEDURE

For the purpose of data collection two tools scientific temper scale and reaction scale were developed by the researcher. As the study is pre-test post-test non-equivalent group design hence the data were collected at the beginning and at the end of experimentation. First of all, scientific temper scale was implemented on both the groups as a pretest to know the initial level of their scientific temper and to make them equivalent. After that the developed integrated strategies were implemented in the experimental group whereas the control group were taught through regular teaching learning process. At the end of second semester scientific temper scale as a post-test was administered again on both the groups. To know the reaction of developed strategies reaction scale was also administered on the experimental group.

3.10.0. DATA ANALYSIS

The data were collected through scientific temper scale was quantitative in nature thus quantitative techniques like mean, SD and non-parametric test Mann whitey U test were used to analyse the data. As the sample was selected on the basis of non-probabilistic method the non-parametric test Mann whitey U test was used. Data collected using reaction scale were analysed using the frequency, percentage and intensity index (Biswal and Das, 2016). All the analysis were done using SPSS 20.0 (Statistical package for Social Science) and MS Excel. Following is the formula used for calculating Intensity Index:

Intensity Index: $[(F_1*5) + (F_2*4) + (F_3*3) + (F_4*2) + (F_5*1)] / F_1 + F_2 + F_3 + F_4 + F_5$

Where F1, F2, F3, F4 and F5 are frequency of SA, A, UD, D, SD respectively and 5,4,3,2,1 are the assigned scale point of SA, A, UD, D, SD respectively.