Chapter - 3

Method and Procedure of the Study

3. Introduction

The present study aims to find the effectiveness of the constructivist strategy to the Chemistry teaching of standard XI. For this purpose, quasi-experimental: Two groups - pre-test post-test purposive sample design was selected. This chapter presents population, sampling procedure, the description of the experimental design, tools used, instructional procedure, method of data collection, and statistical techniques employed for analysis of the data.

3.1 Origin of the Study

Initially, the researcher had gone for a literature review of constructivism and visited the departmental library and various university libraries as well as libraries of education departments; Internet resources also provide a wide range of the subject. The researcher had studied the constructivist approach in Bachelor in Education as a part of the syllabus. The researcher has implemented the constructivist approach as an instructional strategy in research work at Master of Education. When working on the constructivist approach researcher found it interesting. From those days' researcher had decided to work on constructivism. And Guide also suggested that better to work on the topic you are most interested in. The researcher had completed a master's in Chemistry, so it is better to apply Knowledge and understanding of Chemistry-concepts with the illumination of Constructivism. Chemistry-Concepts are very important basic topics at a basic level of science. The Chemistry Concepts are included in Gujarat Higher Secondary Education Board (GHSEB), Central Board Secondary Education (CBSE), and many other state board's Textbooks. The topic is also included at bachelor and master levels in Chemical Sciences and sub-branches of Chemistry in higher education. So, the researcher had decided to apply the constructivist approach to the teaching of Chemistry concepts in standard XI of higher secondary school students.

Experimental researches establish systematic and logical relations between manipulated variable and observed effect. The prominent things of this method are controlled situation,

manipulations of independent variables, and assumption of single variable law given by Mill (Koul, 2009). It is a scientific method in which investigator defines a problem, enumerate objectives, frame hypotheses and test these hypotheses in the light of controlled variable relationship observed.

3.2 Variable of the Study

The research problem includes the following variables;

a) ***Independent variable***- Chemistry Knowledge of the previous standard, Traditional Teaching Method, Constructivist Learning Strategy.
b) ***Dependent variables***-Academic Achievement, Reaction of Students for Constructivist strategy.
c) ***Control variables***-School Environment, Standard, and Duration of teaching.

3.3 Nature of the Study

The Nature of the present study demanded a quasi-experimental approach because it required an experimental method and exploratory method which come under the qualitative methods and quantitative method of pre-test and post-test on two groups design. Since the constructivist approach was used to see whether it can develop constructivist lessons for Chemistry students. The review suggested that though the constructivist approach is related the primary evidence was not available which suggests that the constructivist approach can surely develop Chemistry concepts among students. This means that there was scope to explore the potential of the constructivist approach with the constructivist '5E' leaning model in teaching Chemistry.

3.3.1 Research design of the present study

In the present study Non-Randomized Two Groups Quasi-experimental: Pre-test Post-test design was used. In this study effectiveness of independent variable, method of teaching (two levels): (1) Constructivist teaching-learning method and (2) traditional teaching method was required to be checked on the dependent variable (achievement), thus the researcher decided to use two groups (purposive sample) Quasi-experimental: Pre-test post-test design. The design of the study is presented as below:

$$\mathbf{O_1 \quad E \quad O_2}$$
$$\mathbf{O_3 \quad C \quad O_4}$$

Where,

O_1 andO_3= Pre-test

O_2 and O_4 = Post-test

E = Experimental group (Constructivist Strategy)

C = Control group (Traditional Strategy)

3.3.2 Threats to validity

Validity in the Experimental research method is employing strategies that address potential issues in data collection, data analysis, and the interpretations that might compromise the merging or connecting of the quantitative and qualitative strands of the study and the conclusions drawn from the combination. Here researcher discussed the potential threats to validity and strategies for minimizing the threat.

3.4 Population of the study

The study was carried out in Anand Taluka in the state of Gujarat. There are 21 Gujarati medium schools with higher secondary classes in Anand following Gujarat State Board Syllabus. All class XI students (approximately 2134 students) of the Anand district formed the population of the study (data as per Anand DEO office, 2019).

3.5 Sample of the study

In the present study, samples were selected by the 'convenient Sampling Technique'. As the researcher decided to work at the higher secondary level of the school, the researcher has selected the students of standard XI from the sample science stream schools. The reasons behind the selection of sample for the research work are as follows:

- The Experimental sample school must have permitted to use chemistry laboratory, class, and ICT technology conveniently for research work.
- The students of the Primary level of the school may not mature enough to understand and participate in the learning through Constructivist strategy in chemistry and it can be difficult to gather them at the place of learning strategy manipulation for 50-60 hours. The parents of this level of students may not permit them to attend the program at a place, other than their school.

- The Standard XII students of higher secondary level may not spare proper qualitative and quantitative time for this program due to their preparation for Board-Examination.
- The Standard tenth students of secondary level may not spare proper qualitative and quantitative time for this program due to their preparation for Board-Examination.
- From the higher secondary level, the researcher decided to select standard XI, because standard eight is an entrance of secondary level and mind-set of the students of standard eight may be of the primary level and recently 8th is included in the primary level. Hence, the researcher stratified the sample based on the standard of education.

As the present study was an experimental one, the researcher had decided to select two schools from the population. The researcher selected the Convineant sampling technique in the selection of schools. Gujarati medium schools with higher secondary classes and following Gujarat state board syllabus are ready to provide facilities for implementing the developed Constructivist learning strategy. Two schools of Vallabh Vidyanagar, Anand were purposefully selected for the present study: (1) BAPS Swaminarayan Vidyamandir and (2) R.P.T.P. Higher Secondary School for the experiment group and Control group respectively.

Based on purpose, the researcher intake a whole class as an Experimental group (N=34) and one another intake class as a control group (N=42) by using the Convineant sampling method in two different schools. The experimental group is taught through constructivist 5E's learning approach with different constructivist strategy whereas the control group taught through the traditional approach of teaching. Figure 3.1 shows the sample selection procedure of the study.

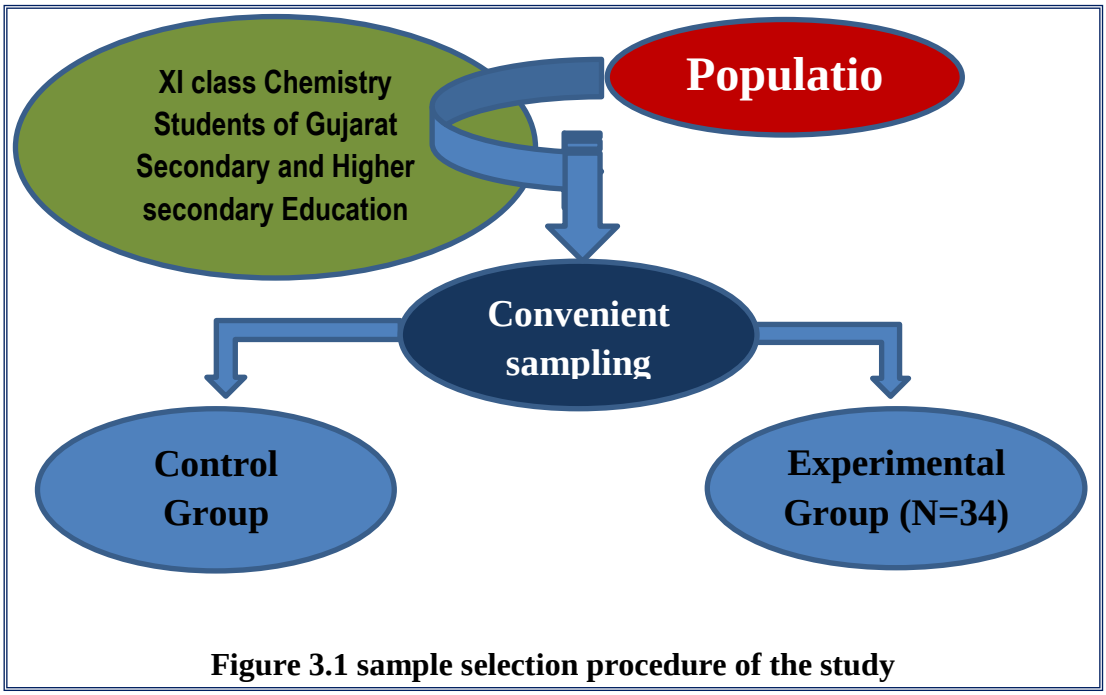

Figure 3.1 sample selection procedure of the study

3.6 Phases of Experimental Research

The research paradigm involves three main phases i.e. planning Phase, intervention Phase and evaluation Phase.

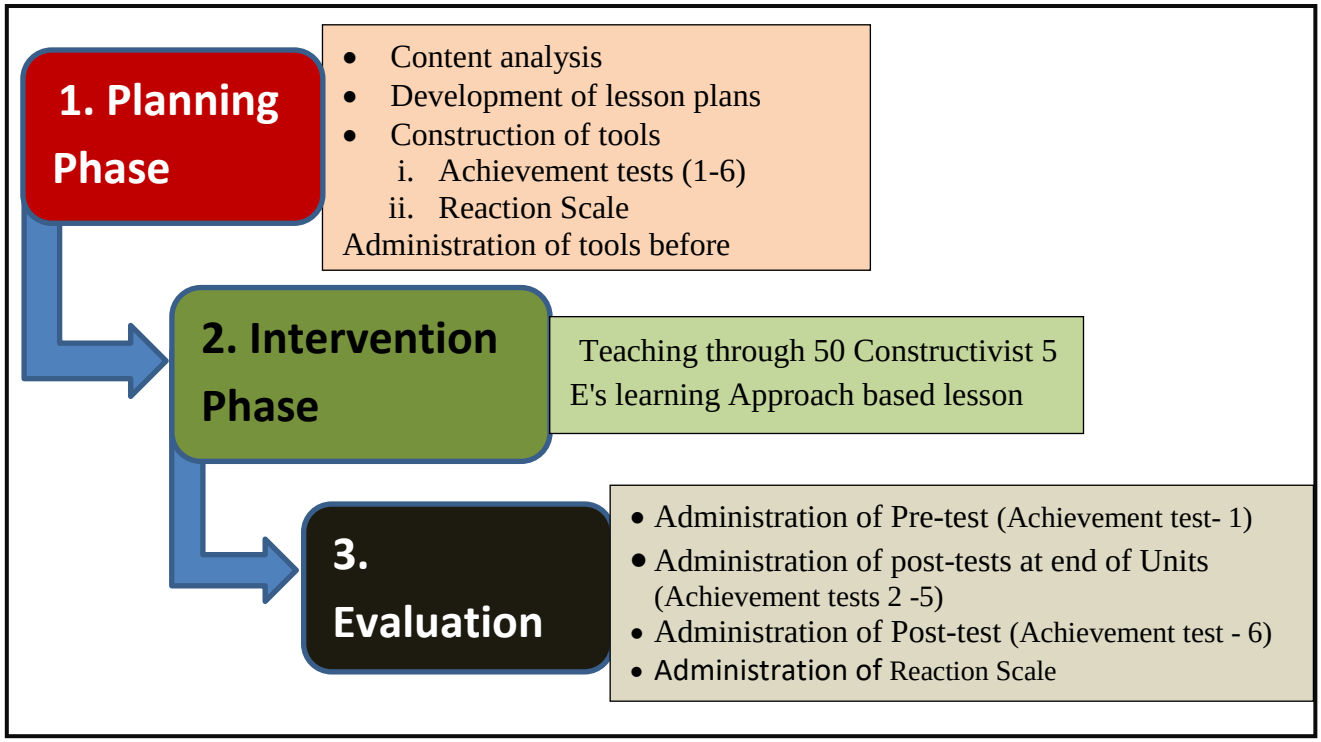

Figure 3.2 display activities of Experimental Phase

3.6.1 Planning Phase

The planning phase is a crucial stage because it includes the program which one needs to develop before doing research. The whole research depends on the planning phase since it gives a base to the research.

This phase entails content analysis of textbooks (Chemistry textbook of standard XI and Science textbook of standard X), development of lesson plans (On Constructivist approach), construction of tests for class XI students (Achievement Test 1-6), and reaction Scale towards strategy) through reviewing researches and test manuals and finally administration of tools before the intervention.

3.6.1.1 Construction of Tools

The following tools was constructed and used for the data collection: In this Experimental study the researcher has used more than one tool. The textbook was revised by the board but the modification was considered in the study.

3.6.1.1.1 Achievement tests (1-6)

The draft of the **Achievement test-1** was prepared with 39 items of which 22 were multiple choice question type, 10 was a very short answer type, 5 was a short answer type and 2 was a long answer type. The vocabulary and the language structure for the level of standard XI students were also kept as a criterion for preparing the items. The per-test was constructed based on the content of five chapters of Chemistry in the tenth standard. Chapters were taken from the Science and technology textbook (2016) of the Gujarat Secondary and Higher Secondary Education Board syllabus. The weightage given to content and objectives is shown in the blueprint (appendix-A).

The draft of the **Achievement tests (2-5)** was prepared with 18 items were multiple choice and one-line answers, a short answer, and long answer type questions. The vocabulary and the language structure for the level of standard XI students were also kept as a criterion for preparing the items. The Achievement tests (2-5) were constructed based on the content of chapters (i.e. 4: Chemical bonding and molecular structure, 7: Equilibrium, 13: Hydrocarbon, and 14: Environmental chemistry) of the standard XI Chemistry textbook of Gujarat Secondary and Higher Secondary Board syllabus. The weightage given to content and objectives is shown in the blueprint (appendix-B).

The draft of the **Achievement test-6** was prepared with 34 items were included multiple-choice, one-line answer, Blank, Pairing, True False, short answer, long answer, and Essay type questions. The vocabulary and the language structure for the level of standard XI students were also kept as a criterion for preparing the items. The achievement test was constructed based on the content of four chapters of the standard XI Chemistry textbook (2018) of the Gujarat Secondary and Higher Secondary Education board. The weightage given to content and objectives is shown in the blueprint (appendix-C).

The blueprints of the achievement tests (1-6) in Chemistry were developed to guide the proportionateness of measuring the performance of the two groups of students who were learned through the same method of teaching. The blueprint reflected the number of questions for each Chapter and indicated the category of objective tested namely knowledge, understanding, application, and skill (HOT). Based on the blueprint the questions of the Achievement tests (1-6) were constructed and the drafts were prepared by the researcher. These drafts were sent to experts from the field of education and to Chemistry subject teachers of standard XI. The suggestions given by them were incorporated and the modified drafts of the test were prepared.

The drafts of the test constructed were scrutinized by experts in education and Chemistry subject teachers of standard XI. They were requested to critically examine the drafts on the following criteria:

- Suitability and hardness of items
- Appropriateness of alternative for each item
- Language and structure of items

The drafts were scrutinized by the experts and suggestions were given for refining the items. Their suggestions were incorporated in the drafts of the achievement tests before the try-out.

- ***Try out of the test***

To try-out, the Achievement tests (1-6) in Chemistry were administered to 50 higher secondary school students of standard XI. The items were analysed for their difficulty index and discriminatory power.

- ***Item analysis***

Firstly, the scored answer scripts were arranged in descending order. Then the two sub-groups of answer scripts i.e., upper 27% of students receiving the highest marks and the lower 27% of students' receiving the lowest marks of the group were separated. The frequency of response to each item for the chosen group was found out. The sum of the frequencies for the two groups was calculated and then item difficulty and discriminative index were found for each item with the help of the formulae given below:

- **Difficulty Value (DV) =** $\frac{\mathbf{R\ (high) + R\ (low)}}{\mathbf{2N}} \times \mathbf{100}$
- **Discrimination Index (DI) =** $\frac{\mathbf{R\ (high) - R\ (low)}}{\mathbf{N}}$

Where, R (high) = the number of correct responses to an item in the high group.

R (low) = number of correct responses to an item in the low group

N = 27% of the total group.

Table No.3.1: Table showing DV and DI of each item for Achievement test-1

Item no.	DV (%)	DI		Item no.	DV (%)	DI
1	41.67	0.50		**21**	54.17	0.42
2	54.17	0.42		**22**	41.67	0.50
3	41.67	0.50		**23**	54.17	0.42
4	16.67*	0.33*		**24**	58.33	0.50
5	50.00	0.50		**25**	50.00	0.67
6	41.67	0.50		**26**	70.83	0.42
7	54.17	0.42		**27**	62.50	0.25
8	41.67	0.50		**28**	45.83	0.25
9	50.00	0.50		**29**	20.83*	0.25*
10	45.83	0.25		**30**	50.00	0.50
11	33.33	0.33		**31**	37.50	0.42
12	54.17	0.42		**32**	25.00	0.33
13	79.17	0.42		**33**	50.00	0.50
14	45.83	0.42		**34**	41.67	0.17
15	41.67	0.17*****		**35**	45.83	0.42
16	58.33	0.83*		**36**	41.67	0.33
17	62.50	0.58		**37**	50.00	0.33
18	54.17	0.58		**38**	8.33*	0.17*
19	58.33	0.50		**39**	45.83	0.42
20	**50.00**	**0.50**				

Table No.3.2: Table showing DV and DP of *each item for Achievement test-2*

Item no.	DV (%)	DI		Item no.	DV (%)	DI
1	50.00	0.02*		**10**	37.50	0.27
2	50.00	0.04		**11**	53.13	0.21
3	68.75	0.04		**12**	50.00	0.24
4	68.75	0.06		**13**	46.88	0.28
5	37.50	0.13*		**14**	50.00	0.28
6	56.25	0.11*		**15**	37.50	0.40
7	50.00	0.31		**16**	40.63	0.39
8	59.38	0.13*		**17**	31.25	0.54
9	34.38	0.26		**18**	43.75	0.41

Table No.3.3: Table showing DV and DP of *each item for Achievement test-3*

Item no.	DV (%)	DI		Item no.	DV (%)	DI
1	34.38	0.44		**10**	53.13	0.56
2	50.00	0.50		**11**	56.25	0.75
3	31.25	0.38		**12**	34.38	0.31
4	40.63	0.44		**13**	28.13	0.56
5	37.50	0.38		**14**	56.25	0.38
6	53.13	0.69		**15**	40.63	0.44
7	50.00	0.50		**16**	31.25	0.13*
8	34.38	0.44		**17**	43.75	0.63
9	40.63	0.31		**18**	18.75	0.25

Table No.3.4: Table showing DV and DP of each item for Achievement test-4

Item no.	DV (%)	DI		Item no.	DV (%)	DI
1	59.38	0.56		**10**	40.63	0.44
2	68.75	0.50		**11**	46.88	0.33
3	59.38	0.44		**12**	37.50	0.38
4	62.50	0.50		**13**	53.13	0.44
5	40.63	0.44		**14**	34.38	0.31
6	37.50	0.38		**15**	53.13	0.56
7	65.63	0.44		**16**	46.88	0.44
8	50.00	0.15*		**17**	37.50	0.50
9	43.75	0.63		**18**	56.25	0.38

Table No.3.5: Table showing DV and DP of *each item for Achievement Test-5*

Item no.	DV (%)	DI		Item no.	DV (%)	DI
1	46.88	0.56		**10**	37.50	0.38
2	50.00	0.63		**11**	43.75	0.38
3	37.50	0.50		**12**	53.13	0.69
4	34.38	0.44		**13**	37.50	0.25
5	40.63	0.44		**14**	31.25	0.38
6	25.00	0.15*		**15**	40.63	0.31
7	59.38	0.31		**16**	43.75	0.38
8	56.25	0.63		**17**	37.50	0.50
9	40.63	0.56		**18**	46.88	0.19*

Table no.3.6: Table showing DV and DP of each item for Achievement test-6

Item no.	DV (%)	DI		Item no.	DV (%)	DI
1	45.83	0.58		**18**	54.17	0.58
2	50.00	0.67		**19**	50.00	0.50
3	50.00	0.33		**20**	54.17	0.42
4	37.50	0.58		**21**	45.83	0.42
5	37.50	0.42		**22**	37.50	0.58
6	58.33	0.33		**23**	58.33	0.50
7	37.50	0.58		**24**	50.00	0.73
8	50.00	0.50		**25**	70.83	0.42
9	50.00	0.33		**26**	66.67	0.17
10	33.33	0.50		**27**	41.67	0.33
11	54.17	0.58		**28**	45.83	0.58
12	41.67	0.50		**29**	41.67	0.50
13	83.33*	0.33		**30**	4.17*	0.08*
14	45.83	0.42		**31**	54.17	0.58
15	41.67	0.17*		**32**	41.67	0.50
16	58.33	0.78		**33**	50.00	0.33
17	62.50	0.58		**34**	33.33	0.50

Item selection: As suggested by Abu-Hashem (2008), the items with a difficulty value in the range of 21-80% and discriminating power greater than 0.20 were selected for the final test. '*' signed items were re-constructed for the final tool drafts. All '*' assign items reconstructed as per weightage and objectives as shown in table 3.1, 3.2, 3.3, 3.4, 3.5, and 3.6.

Reliability: The test Split-half reliability and Cronbach's alpha reliability was established for the Achievement test in Chemistry.

- ***Split-half reliability***: Test Split-half reliability method was adopted to establish the reliability of the Achievement test in Chemistry. The test was administered to 50 students of standard XI from one school other than the sample school. The consistency coefficient was calculated for the test Split-half using Pearson's product-moment correlation technique. The obtained consistency coefficient was 0.84, 0.97, 0.93, 0.95, 0.89, and 0.94 that indicated high reliability of the test.

- ***Cronbach's alpha reliability***: Cronbach's alpha method was employed to determine the reliability of Achievement tests (1-6) in Chemistry. Cronbach's alpha reliabilities for Achievement tests (1-6) were found to be 0.92, 0.94, 0.91, 0.95, 0.93, and 0.95 which indicating high reliability.

Validity: Face validity and content validity were established for the Achievement test in Chemistry.

- ***Face validity***: To establish the validity of the tool the researcher established its face validity. The researcher, supervisor, and experts from the field of Chemistry teaching approved the newly developed achievement tests (1-6) in terms of their face validity.

- ***Content validity***: To establish its content validity, the researcher sent the final tool to ten experts in the field of education. The experts unanimously approved its appropriateness for the intended purpose. Hence the Achievement test in Chemistry possessed content validity. Achievement tests (1-6) in Chemistry are presented in Appendix – D, Appendix – E, Appendix – F, Appendix – G, Appendix – H, and Appendix – I.

3.6.1.1.2 Student's Reaction Scale (SRC)

A Reaction Scale was constructed to know the reaction of students towards Social Constructivist Strategies for teaching-learning Chemistry. The researcher constructed 20 item statements to collect the opinion of students regarding the method used for teaching, the classroom environment and evaluation techniques adopted, the relationship between the teacher and the students, and among the students, daily assignments. The Reaction Scale was checked for content validity by the guide, experts, and Chemistry teachers. Some items were modified based on the suggestions of the experts. Close-ended 34 items were retained for the final form of the reaction scale with five options- always, frequently, occasionally, rarely, and

never were the final form of the reaction scale. Students ticked the option that they felt indicated their experience in learning through Constructivist strategies. This reaction scale was also sent to experts for their suggestions (Appendix – J). The Item statements of the reaction scale were retained except for some modifications in the structure as per suggestions of experts and then finalized (Appendix - L).

3.6.1.1.3 Social Constructivist Lesson plans

Lesson plans were designed for the selected content taught by Social Constructivist Strategies. The lesson plans based on SCS were developed based on the background knowledge and experience of the students following the principles of Social Constructivism. Sixty lessons were employed for the selected four units in the Chemistry syllabus of standard.

Lessons were planned based on the "5E Model" developed by *Roger Bybee* of 'The Biological Science Curriculum Study'. The 5E model was developed based on the Constructivist principles of learning. The meaning of 5E's is Engage, Explore, Explain, Elaborate, and Evaluate.

Engage this stage the task is introduced. Connections to past learning and experience are invoked. A demonstration of an event, the presentation of a phenomenon or problem, or asking pointed questions are used to focus the learners' attention on the tasks that will follow. The goal is to spark their interest and involvement.

Explore: Learners should take part in activities that allow them to work with materials that give them a 'hands-on' experience of the phenomena being observed. Simulations or models, whose parameters can be manipulated by learners, are provided so that they can build relevant experiences of the phenomena. Questioning, sharing, and communication with other learners are to be encouraged during this stage. The teacher facilitates this process.

Explain: The focus at this stage is on analysis. The learner is encouraged to put observations, questions, hypotheses, and experiences from the previous stages into language. Communication between learners and learner groups can spur the process. The instructor may choose to introduce explanations, definitions, mediate discussions or simply facilitate by helping learners find the words needed.

Elaborate: Using the understanding gained in the previous stages, the learners are to be encouraged to build and expand upon it. Inferences, deductions, and hypotheses can be

applied to similar or real-world situations. Varied examples and applications of concepts learned to strengthen mental models and provide further insight and understanding.

Evaluate: Evaluation is to be on-going and should occur at all stages, to determine that learning objectives have been met and misconceptions avoided. Any numbers of rubrics, checklists, observation, concept map, or other evaluation tools are used. If interest in a particular aspect or concept is shown, a further inquiry should be encouraged and a new cycle that builds upon the previous one can begin. Inquiries may branch off and inspire new cycles, repeating the process in a spiralling fractal of interrelated concepts, where instruction is both structured and yet open to investigation.

The 5E model is the most effective way of engaging students in learning. Lesson plans adopting SCSs for the teaching of the selected content were drafted and prepared based on the 5E model by the researcher. This draft was sent to experts from the field of education and to a few standard XI Chemistry teachers. The suggestions given by them were incorporated and the modified final Lesson plans were prepared. Three Social Constructivist lesson plans in Chemistry were tried out on secondary school students of standard XI of a different school. Sample Social Constructivist Chemistry lesson plans presented in Appendix-K.

3.6.2 Implementation Phase

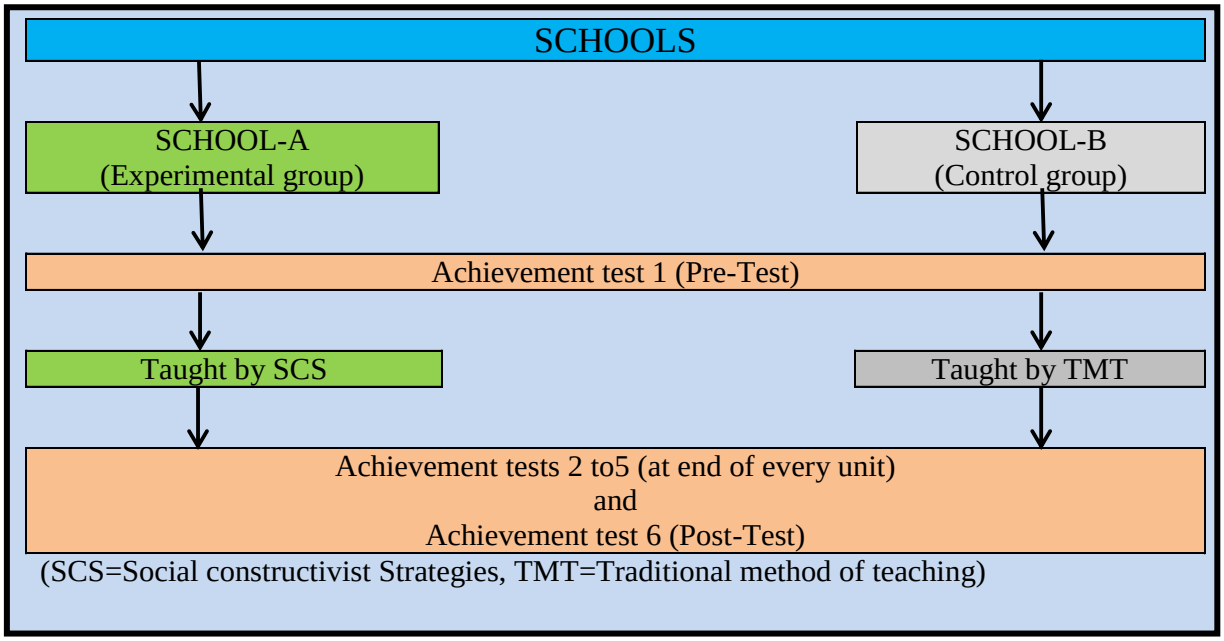

Figure 3.3 Implementation of experiment in schools

First, Achievement test-1 was administered for knowing students' previous knowledge about chemistry. Second, the respective 4 Unit (Semester -2: Unit1- Chemical Bonding and Molecular Structure, Unit4 – equilibrium, Unit6 – hydrocarbon and Unit7- Environmental chemistry) in chemistry was taught to the experimental group using the constructivist strategy. Here, the lesson plans for teaching selected content of chemistry based on SCS (using 5E's learning model) for standard XI. The lesson plans was given to experts in the field of Education for scrutiny and the suggestions of experts was incorporate. These lessons were tried out and changes were made to suit the classroom conditions. Achievement tests (2 to 5) were taken after each completion of the Unit in both groups. Last, implement achievement test-6 as post-test in both groups, and researcher was implemented reaction scale for collecting reactions of students towards constructivist strategy in experimental group.

The intervention was implemented in School from 21st August 2019 to 28th December 2019. The researcher has taught 4 Units (Unit4 – Chemical Bonding and Molecular Structure, Unit7 – equilibrium, Unit6 – hydrocarbon, and Unit7 – Environmental chemistry) were taught using the different strategies for Higher Secondary Chemistry of Standard XI. The researcher had taught one hour alternative days and sometimes on Sunday in a week (approximately 60 hours). Contain, Constructivist techniques, and period are given in Table 3.7.

Table 3.7 Contain, Constructivist techniques, and period

Unit (Constructivist Approach and Strategy)	**Lesson no.**	**Improvement perceptions Contain Topics**	**Activity and Techniques**
Chemical bonding and Molecular Structure (5E Model and Cooperative learning)	1	Chemical bonding	Demonstration Atomic-Model Showing, students will prepare ball and stick model for selected molecules and followed by discussion
		Kossel-Lewis Approach to Chemical Bonding	
	2	Covalent Bond	
		Lewis Representation of Simple molecules- Lewis structure	
	3	Formal Charge and its calculation	
	4	Octet Rule	
		Limitations of the Octet Rule	
	5	Ionic or Electrovalent Bond	
		Lattice Enthalpy	
	7	Bond Parameters	
	8	Resonance Structures	
		Polarity of Bonds	

Chemical bonding and Molecular Structure (5E Model and Cooperative learning)	9	VSEPR theory	Demonstration Atomic-Model Showing, students will prepare ball and stick model for selected molecules and followed by discussion
		Valence Bond Theory (VBT)	
	10	Orbital Overlap Concept	
		Directional Properties of Bonds	
		Overlapping of Atomic Orbitals	
	11	Types of Overlapping and Nature of Covalent Bonds	
		Hybridisation	
		Types of Hybridization- sp,sp2,sp3	
	12	Hybridization of elements Involving d-Orbitals	
	13	Molecular Orbital Theory	
		Formation of MO: linear Combination of atomic orbitals	
	14	Conditions for the combination of Atomic Orbitals	
		Types of Molecular Orbitals	
	15	Energy level Diagram for MO's, electronic configuration and molecular behaviour	
	16	Bonding in some homo-nuclear Diatomic Molecules	
		H-bonding, its types	
Equilibrium (5E Model and Problem solving)	17	Chemical Equilibrium	Demonstration Atomic-Model Showing, students will prepare ball and stick model for selected molecular equilibrium and followed by discussion
		Equilibrium in physical process	
	18	General Characteristics of equilibria involving Physical process	
	19	Equilibrium - Dynamic Equilibrium	
		Low of Chemical Equilibrium and Equilibrium Constant	
	20	Homogeneous Equilibrium: Gases System	
		Heterogeneous Equilibrium	
	21	Applications of Equilibrium Constants : Predictions of extensions of reactions and Predication of Directions of Reactions	
	22	Calculating Equilibrium Concentration	
	23	Relations between K, Q and G	
	24	Effects of Concentration change	
		Effects of pressure change	
	25	Effect of Inert gas addition	
		Effects of Temperature change	
		Effects of Catalyst	
	26	Ionic Equilibrium in Solution	
		Acid, Base and Salts: Definitions, Ionization, Ionization constant of water	
		pH scale	

Equilibrium (5E Model and Problem solving)	27	Ionization of weak acid and week base	Demonstration Atomic-Model Showing, students will prepare ball and stick model for selected molecular equilibrium and followed by discussion
		Relations between K_a and K_b	
	28	Di- and Poly- protic Acid and Base	
		Factors affecting on acid strength	
	29	Common ion effects in the Ionization	
		Hydrolysis of Salts and pH of their solutions	
	30	Buffer solutions	
		Solubility Equilibria of Sparingly soluble salts	
	31	Solubility product constant	
		Common ion effects on solubility of Ionic salts	
Hydrocarbon (5E Model and Concept mapping)	32	Tetra valance of Carbon: shape of hydrocarbon compounds	Demonstration Atomic-Model Showing, charts students will prepare ball and stick model for selected molecular equilibrium and followed by discussion
		Types of C-C bond	
		2D and 3D Structural representations of hydrocarbon Compounds	
	33	Classification of Hydrocarbon	
	34	Types of Reactions	
	34	Alkane : Methane, IUPAC nomenclature, Isomerism	
	35	alkane: Preparation	
	36	Properties, Confirmation : Sawhorse and Newman	
	37	Alkenes: ethene	
	38	IUPAC nomenclature, Isomerism	
	39	alkene: Preparation, Properties	
		Confirmation : Cis and Trans	
	40	Chemical Characteristics	
		Markovenikov-antimarkonikov rule	
	41	Alkynes: ethyne	
	42	IUPAC nomenclature, Isomerism	
	43	alkynes: Preparation	
	44	Properties, Chemical Characteristics	
	45	Aromatic Hydrocarbon: Benzene, ,	
	46	IUPAC nomenclature	
	47	Isomerism	
	48	Aromaticity - Huckel Rule	
		Aromatic Hydrocarbon: Preparation, Properties	
	49	Chemical Characteristics	
	50	effect of Mono-substituted Benzene	
		Carcinogenicity and Toxicity	
Environmental Chemistry (5E Model and	51	Environmental Pollution	
	52	Atmospheric pollution: Tropospheric pollution- 1. Gases pollutants, 2. Particle pollutants;	

Cooperative learning)	53	Global warming, Acid rain	Demonstration, students will prepare Charts and Poster for selected environment sensational topics and followed by discussion
	54	Stratospheric pollution: Ozone layer break	
	55	Water pollution: Causes	
	56	International Standards	
	57	Soil Pollution: Pesticides	
	58	Industrial waste	
	59	Strategies for Control of Environmental Pollution	
	60	Green Chemistry: Concept and Day- to-day life	

3.6.3 Evaluation phase

This phase is followed by administered four different end units' achievement tests in Chemistry. Chemistry Post-Achievement test and reaction scale towards Constructivist strategy was applied on the groups to measure the effectiveness of developed lesson plans on achievement and reaction of the students towards Constructivist strategy in chemistry after intervention phase. The instructions for administration are the same as for the pre-test.

3.7 Statistical techniques used for analysis of data

The following statistical techniques were used for data analysis to verify the different hypotheses formulated for the study.

- ***Mean*:** The mean value is computed as a measure of the central tendency of the distribution of achievement scores.
- ***Standard Deviation*:** This is determined to study the variation in the scores and to do other various computations i.e. variance.
- ***Graphical Representation of data*:** It is drawn to clarify the comparisons tests (pre-test and post-tests) between mean and SD of groups properly.
- ***Inferential Statistics*:** Non-parametric inferential statistics are used in the present investigation to test the various hypotheses of the study, as well as to draw a definite conclusion based on the obtained results i.e. Mann Witney U-Test.

3.8 Delimitations of the Study

To make the study more specific and methodical it has been delimited with certain points:

1. Academic Achievement is delimited to Achievement in Chemistry.
2. 5E model of constructivist approach is considered to develop constructivist lesson plans in the present study.
3. The tool developed by the investigator was not standardized and only the validity and reliability were established.