Chapter 3

METHODOLOGY OF THE STUDY

3.0 INTRODUCTION

This chapter deals with the specifications of the methodology employed to study the objectives stated in chapter 1 and to test the hypotheses of the study. It deals with the details of the research design, procedures followed, tools of the research, data collection procedure and the data analysis techniques employed in the present study.

3.1 DESIGN OF THE STUDY

The present study was a normative survey in nature. A normative study is essentially a cross – sectional, mostly of the "what exists" type study. It does not aspire to develop an organized body of scientific laws but provides information useful to the solution of local problems. It may, however, provide data to form the basis of research of a more fundamental nature (Sukhia, 1963). For the present study, Mean, median, mode and standard deviation were considered as the norms.

3.2 POPULATION

There were total 282 secondary schools managed by GSEB in Kachchh district. From those 282 schools, 186 government schools; 96 grand-in-aid and 96 private schools were selected as population for data collection. All class IX students, in the academic year 2018-19, of those schools formed the population for the present study.

3.3 SAMPLE

The sample schools were selected through Multistage cluster sampling technique for the present study. Multistage cluster sampling is employed when it is difficult to get the complete list of the members of the population, in this case, all students of class IX (Cresswell, 2015) but the list of groups or the clusters is available that is schools (Vogt, 2005). Plot of multistage cluster sampling for the present study is shown below:

1st stage: 5 talukas out of total 10 talukas of Kachchh district were selected randomly by lottery method.

2nd stage: 7 government schools + 8 grant-in-aid schools + 5 Gujarati medium private schools + 8 English medium private schools (total 28 schools) were selected through lottery method of random sampling technique.

3rd stage: All students i.e. 2443 students of class IX belonging to 28 schools selected in second stage were selected using cluster sampling.

3.4 TOOLS FOR DATA COLLECTION

To achieve objectives of the present study, a test to measure cognitive abilities in science and technology was constructed. Detailed procedure was followed by the researcher for the construction of tool is given as under:

3.4.1 Cognitive Ability Test for Science (CATS): Researcher constructed a test containing Multiple Choice Questions (MCQ) in science and technology subject. Items focused on ***Remembering, Understanding, Applying, Analyzing and Evaluating*** levels of Bloom's revised taxonomy (Anderson et al., 2001). The Constructed test was standardized by researcher. The questions focused on all the mentioned levels of cognitive domain.

3.4.2 Creativity Test for Science (CTS): Researcher constructed a test focusing on ***Creating*** level of Bloom's revised taxonomy (Anderson et al., 2001). The test contained divergent type question.

3.5 CONSTRUCTION OF COGNITIVE ABILITY TEST FOR SCIENCE (CATS)

For construction and standardization of CATS, below mentioned steps adapted from Groundlund and Linn (1990) were followed:

3.5.1 Content analysis

The researcher carefully analyzed the content of science and technology textbooks of class six to class eight designed by Gujarat State Board of School Textbooks (GSBST). Researcher referred the content of these textbooks for the preparation of CATS and CTS. Based on the content analysis, researcher established horizontal as well as the vertical relationship among the chapters of science and technology textbooks of class VI, VIII and VIII designed by Gujarat State Board of School Textbooks (GSBST). Following are the identified concepts with their brief description:

3.5.1.1 Chemistry:

1). **Elements, Compounds, mixtures and molecular structure:** Symbols of elements, some commonly known mixtures and compounds; structure of atom, atomic numbers for different elements, electron configuration, formation of molecules as a result of ionic and covalent bonds.

2). **Separation of substances:** Various types of mixtures- solid, liquid, gas, solid and gaseous, liquid and gaseous, solid and liquid, solid, liquid and gaseous, necessity for separation, methods of separation- picking, sieving, winnowing, decantation, filtering, magnet method, sublimation, evaporation and distillation.

3). **Fossil fuels:** Types of fossil fuels – mineral coal, petroleum, natural gas.

4). **Classification of matter:** Basic concepts of acid, base, salt, solid, liquid and gas.

5). **Air and preparation of gases:** Constituents of air, preparation of Oxygen, CO_2, Hydrogen, Nitrogen and their physical and chemical properties and uses.

6). **Metal - non metal:** Physical properties, chemical properties and uses of metals and non-metals, uses of alloys, mixed compounds and oxidation, reduction and redox process.

7). **Combustion:** Factors required for combustion – oxygen, fuel and temperature of the substance, parts of flame.

8). **Manmade material:** Plastic, rubber, glass and paper.

3.5.1.2 Physics:

1). **Magnetism:** Introduction of the magnet and attractive, directive and repulsive properties of magnet and its application in compass.

2). **Simple machine:** Types of simple machine such as lever, slope, screw, wedge, wheel and axle and pulley and their usefulness.

3). **Measurement:** Measurement of length, area, time, mass, weight and volume.

4). **Modes of heat transfer:** Methods of thermal transformation such as conduction, convection and radiation ; good and poor conductors of heat; thermometer.

5). **Energy:** Non- renewable and renewable sources of energy; and transformation of energy and; law of conservation of energy.

6). **Our solar system:** Stars, Star clusters, planets and satellites.

7). **Laws of light:** Terminology related to reflection of light, law of reflection; law of refraction, refractive index.

8). **Curved mirrors and reflectors: :** Terminology related to characteristics of images formed by convex and concave mirrors, its use in solar cooker; image formed by concave and convex lenses, their uses.

9). **Motion, force and speed:** Types of motion – linear, circular, periodic and oscillatory, definition of speed, effects of force and types of force-muscular, magnetic, gravitational and frictional.

10). **Air pressure:** Application of air pressure in syringe, hand pump, straws.

11). **Electricity:** Open and closed circuit, conductors and insulators, fuse, M. C. B. and vampire power, series and parallel connection.

12). **Sound:** Reasons for production of sound- collision, vibration and rubbing of things, propagation of sound in different media, echo and its application.

3.5.1.3 Biology:

1). **Water:** Water cycle, water harvesting; and physical and chemical properties of water, soft and hard water, water purification, solvent, soluble and solution.

2). **Animal kingdom and its survival:** Types of animals, food chain and food web (producers, primary, secondary and tertiary consumers), Adaptation of avions, aquatic and domestic animals and of plants. Endangered animals, birds at the risk of extinction.

3). **Organ systems of human body:** Functioning of Digestive system, Respiratory system and Circulatory system; Functions and types of muscular system; functions of nervous system, sensory organs, functions of endocrine glands; male and female reproductive system, organs of excretory system.

4). **Life cycle of a seed:** Dicot and monocot seeds, dispersal of seeds, factors required for germination of seeds; types of plants-herbs, shrub, tree and climber, types of roots-tap and fibrous, types of stem-erect, climbing, creeper and underground, types of leaves-simple and compound; functions and special functions of roots, stem and leaves (photosynthesis); parts of a flower, pollination, fertilization and types of fruits.

5). **Agricultural practices:** Agricultural practices, soil erosion, irrigation methods; modern methods of agriculture, types of hydroponics.

6). **Cell and microorganism:** Parts and functions of cell; benefits and harmful effects of microorganism –fungi, protozoa, bacteria, virus and algae.

7). **Constituents of diet:** Carbohydrates, fatty acids, protein, vitamins, mineral elements and water and balanced diet.

8). **Changes around us:** Natural and manmade changes, reversible and non-reversible changes, physical changes, slow and fast changes, non-agreeable and desirable changes, periodic and non-periodic changes.

9). **Environmental equilibrium:** Air, water and soil pollution and wastage of energy; Air pollution due to smoke and radiation, effects of air pollution, carbon cycle, green-house effect,

acid rain, use of LPG and CNG, PPM-measure of air pollution; endangered animals, birds and aquatic animals and trees and the reasons; harms caused due to plastic, e-waste and bio medical waste; noise pollution.

3.5.2 Construction of items for item pool

Based on analyzed content of science and technology textbooks researcher constructed an item pool which consisted of 568 test items for first five levels of cognitive domain given by Anderson et. al. (2001) viz., Remember, Understand, Apply, Analyze and Evaluate. The blue print of the item pool is shown as below:

Table 3.1 Item pool for CATS

	Concepts	Levels					
		Remember	Understand	Apply	Analyze	Evaluate	Total
#	**Chemistry**						
1	Elements, Compounds, mixtures and molecular structure	3	6	3	2	1	16
2	Separation of substances	5	2	2	4	1	15
3	Fossil fuels	9	4	2	1		16
4	Classification of matter	6	5	6	3		20
5	Air and preparation of gases	15	7	2	1		25
6	Metal - non metal	10	3	6	2		21
7	Combustion	11	3	3	0		17
8	Manmade material	7	3	2	1		13
•	Total	**67**	**33**	**26**	**13**	**2**	**141**
#	**Physics**						
1	Magnetism	5	3	4	1	1	14
2	Simple machine	3	2	2			8
3	Measurement	1	3	8			12
4	Modes of heat transfer	3	5	4	1	2	15
5	Energy	4	1	3			8
6	Our solar system	2	2	2			7
7	Laws of light	5	6	4	2	2	20
8	Curved mirrors and reflectors	4	4	1	1	1	13
9	Motion, force and speed	3	3	4	2	1	14
10	Air pressure	4	1	1	1	2	9
11	Electricity	3	5		3	1	13
12	Sound	4	0	5	2	1	13

•	Total	**41**	**35**	**38**	**13**	**11**	**138**
#	**Biology**						
1	Water	5	5	2	3	1	17
2	Animal kingdom and its survival	8	5	1	1	1	18
3	Organ system of human body (Human organ system)	83	36	17			136
3.1	Digestive system	11	2	3			16
3.2	Respiratory system	3	5	4			12
3.3	Circulatory system	9	7	1			17
3.4	Musculo-skeleton system	8	4	2			14
3.5	Nervous system	23	11	2			36
3.6	Endocrine system	8	2	3			13
3.7	Reproduction system	14	3	1			18
3.8	Excretory system	7	2	1			10
4	Life cycle of a seed	17	10	8	6	2	44
5	Agricultural practices	7	5				12
6	Cell and microorganism	20	5	2			27
7	Constituents of diet	7	7	4	1	1	21
8	Changes around us	2	3	5	2	1	14
9	Environmental equilibrium	5		1			6
•	Total	**154**	**76**	**40**	**13**	**6**	**289**
	Grand Total	**262**	**144**	**104**	**39**	**19**	**568**

The test contained Multiple Choice Questions (MCQs). Researcher framed as many test items as possible so that experts could get a wide range of choice to think and select item kept in mind the following criteria for writing the test items:

- Each item tested only one outcome.
- Each question had at least four alternates.
- Language of the instruction was clear and simple.
- Each item had only one correct answer.

3.5.3. Experts' Validation

The item pool of CATS was sent to experts of science and technology subject. The experts were either working as a science teacher in secondary/higher secondary school or assistant professor of science method in teacher education institutes. The minimum qualification of the experts was M.

Sc., B.Ed. However, some experts had the qualification M. Sc., M. Ed. while majority of them had earned a Ph. D. in Education too. The tool was to be examined in terms of following criteria:

- The instruction part given for each test item.
- The coherence between instruction and the test item.
- The language used in preparation of test items.

Apart from this, experts were also asked to select the most appropriate items for each level of the taxonomy for every identified concept. It is to be noted here that no any prescribed number of items was decided for selection of the items. The purpose was to prepare a comprehensive and holistic tool for the present study.

Moreover, researcher presented the item pool of CATS in an open forum at Department of Education, Faculty of Education and Psychology, The Maharaja Sayajirao University of Baroda, Vadodara. There were 15 participants present in the forum. The entire item pool of CATS was presented in front of them and their suggestions and comments were considered for preparing first draft of CATS.

Following part presents gist of comments and suggestion received from the experts:

- Avoid repeating similar kind of questions. For instance, remember level items related to atomic symbols of elements were to be reduced to avoid repetition of test items. Similarly, items related to terminologies of certain concepts such as convex and concave mirrors, reflection, refraction, parts of human body system were to be reduced.
- There were some items which had received huge convergence of selection form the experts.
- After thoroughly studying the tool, experts selected the most appropriate items for the first draft of CATS. The number of test items selected by the experts ranged from 180 to 225.

3.5.4. Pre-pilot testing

Researcher personally administered the constructed item pool on a group of 13 students other than the sample to examine it from language aspect and unambiguity of items. The item pool was administered in parts for 3 days on the same group of students. Researcher selected such a small group of students for pre-pilot study so that she could attend each student's queries take note of the discussion points during administration of the tool. There was no any time limit for test completion as the purpose of the administration was not to measure the speed of the students for responding. Following are the conclusions drawn from students' queries and the discussion:

- The language used by the researcher in the test items was not understandable by class IX students. Students did face difficulty in understanding higher order questions of the tool. They frequently needed clarifications and explanations of the terms as well as the statements of the items.
- Though the tool was prepared with the purpose of covering all the identified concepts of science and technology textbook, it was too long for the students.
- However, students felt challenged while answering the test items.
- According to students, the tool contained some thought provoking questions which were not directly answerable from the textbook content. Hence, the tool was valid in itself for higher order level question.

Based on the findings of the pre-pilot administration and experts' comments and selection in validation on the item pool, a draft of the tool was prepared which contained 192 Multiple Choice Questions. Following table shows specifications of the tool with respect to concepts and level of test items (Appendices A & B):

Table 3.2 Blue print of CATS for pilot study

No.	Concepts	Remember	Understand	Apply	Analyze	Evaluate	Total
	Chemistry						
1	Elements, Compounds, mixtures and molecular structure	1	1	4		2	
2	Separation of substances		2		2		
3	Fossil fuels	4	2	1	1	1	
4	Classification of matter	1	2	2	1		
5	Air and preparation of gases	5	3	1	1		
6	Metal - non metal	5	1	4			
7	Combustion	6	1	2			
8	Manmade material	3	2	2	1		
		25	**14**	**16**	**6**	**3**	**64**
	Physics						
1	Magnetism	1	1	2			

2	Simple machine	2	1	1		1	
3	Measurement	1	2	4			
4	Modes of heat transfer	1	3		1	1	
5	Energy		1	3			
6	Our solar system	1	1	1			
7	Laws of light	3	2	1	1	1	
8	Curved mirrors and reflectors	1	3				
9	Motion, force and speed	2	2	1		1	
10	Air pressure	3	1	1	1	1	
11	Electricity	2	3		1		
12	Sound	1	1	1	1		
		18	**21**	**15**	**5**	**5**	**64**
	Biology						
1	Water	3	2		2	1	
2	Animal kingdom and its survival	4	1		1	1	
3	Organ system of human body (Human organ system)	18	3	6			
4	Life cycle of a seed	2	3	1	2		
5	Agricultural practices	1	1				
6	Cell and microorganism	3	1				
7	Constituents of diet	1	1				
8	Changes around us			1		1	
9	Environmental equilibrium	2	1	1			
		34	**13**	**9**	**5**	**3**	**64**
	Grand Total	**77**	**48**	**40**	**16**	**11**	**192**

3.5.5. Pilot study

3.5.5.1 Empirical evidence

Researcher conducted pilot study for gathering empirical evidence. The sample was 312 class IX students. The students of government, grant-in-aid and private schools selected randomly were the subjects for pilot study. The tool was administered in both Gujarati and English medium schools.

After administration, the total scores of the students obtained in the test were calculated which is presented in the following table:

Table 3.3 Scores of Students in the CATS for pilot study

SNo.	Marks	SNo.	Marks	SNo.	Marks	SNo.	Marks	SNo.	Marks
1	93	31	77	61	115	91	83	121	69
2	70	32	74	62	69	92	82	122	88
3	88	33	71	63	80	93	83	123	67
4	90	34	73	64	109	94	71	124	109
5	81	35	68	65	112	95	138	125	77
6	66	36	79	66	77	96	92	126	84
7	87	37	52	67	81	97	92	127	70
8	80	38	82	68	75	98	49	128	71
9	87	39	57	69	84	99	97	129	106
10	63	40	84	70	99	100	109	130	63
11	49	41	74	71	108	101	87	131	87
12	72	42	51	72	83	102	84	132	75
13	80	43	67	73	76	103	97	133	106
14	60	44	65	74	84	104	74	134	86
15	78	45	82	75	104	105	71	135	84
16	79	46	81	76	62	106	97	136	88
17	99	47	84	77	87	107	116	137	93
18	79	48	78	78	70	108	59	138	89
19	60	49	66	79	76	109	100	139	104
20	75	50	74	80	64	110	63	140	98
21	62	51	91	81	53	111	150	141	76
22	67	52	72	82	79	112	89	142	97
23	77	53	53	83	69	113	91	143	70
24	63	54	78	84	46	114	97	144	98
25	70	55	81	85	73	115	112	145	76
26	61	56	73	86	80	116	93	146	64
27	61	57	91	87	72	117	73	147	63
28	54	58	110	88	69	118	62	148	80
29	79	59	70	89	116	119	95	149	84
30	62	60	66	90	66	120	58	150	81

SNo.	Marks
151	94
152	80
153	77
154	79
155	84
156	78
157	72
158	67
159	67
160	61
161	62
162	75
163	73
164	72
165	81
166	79
167	64
168	61
169	52
170	64
171	63
172	70
173	71
174	52
175	77
176	72
177	73
178	50
179	66
180	63

SNo.	Marks
181	68
182	70
183	64
184	52
185	52
186	69
187	65
188	63
189	57
190	62
191	48
192	64
193	82
194	54
195	56
196	76
197	42
198	71
199	89
200	57
201	57
202	86
203	100
204	81
205	50
206	92
207	79
208	71
209	68
210	64

SNo.	Marks
211	60
212	45
213	50
214	38
215	102
216	97
217	68
218	73
219	65
220	68
221	75
222	68
223	57
224	83
225	68
226	71
227	61
228	107
229	85
230	84
231	83
232	73
233	83
234	86
235	80
236	103
237	116
238	108
239	101
240	65

SNo.	Marks
241	54
242	67
243	61
244	64
245	74
246	50
247	60
248	61
249	60
250	59
251	60
252	58
253	55
254	53
255	65
256	61
257	48
258	67
259	51
260	81
261	66
262	87
263	65
264	66
265	63
266	65
267	68
268	62
269	44
270	65

SNo.	Marks
271	73
272	86
273	67
274	58
275	60
276	58
277	61
278	45
279	68
280	61
281	54
282	53
283	48
284	68
285	59
286	54
287	59
288	52
289	46
290	53
291	74
292	43
293	70
294	99
295	86
296	62
297	92
298	60
299	69
300	75

SNo.	Marks	SNo.	Marks	SNo.	Marks	SNo.	Marks	SNo.	Marks
301	55	304	78	307	60	310	54	-	-
302	75	305	61	308	61	311	57	-	-
303	59	306	69	309	66	312	56	-	-

SNo. = Student Number

a). Item analysis

Item analysis brings into light general areas requiring attention; reveal ambiguities, technical defects with regard to language of instruction, mode of presentation. The test constructed being a norm reference test, a suitable procedure of comparing upper and lower of 27% of the group on the basis of the test performance is adopted. The responses of the remaining pupils not included in the analysis, were assumed to follow the same trend as those in the upper and lower groups.

Step I: After collecting the test papers from the students, students responses were scored, one mark for the correct response and no marks for the incorrect responses.

Step II: When all the test papers were scored they were arranged in ascending order of marks. The upper 27% and the lower 27% of the students arranged in ascending order with regard to their scores were selected. Here, 85 students made 27% of the total. Therefore, the item analysis process was done with responses of 170 students.

Step III: the scores were tabulated against the test items. For each test item responded correctly, entries were made in the table. Thus, total number of correct responses for each item were found. The tabulation of responses facilitated in obtaining estimate of item difficulty and item discrimination power. Although item analysis revels the general effectiveness of a test item, it is desirable to obtain item difficulty and discrimination power.

b). Item difficulty (P value)

The item difficulty of a test item is indicated by the percentage of pupils who get the correct item. It was calculated by using the formula given by Groundlund and Linn (1990). The items left unanswered by the students were omitted from the item analysis procedure.

c). Item discrimination (D value)

An item discriminates in a positive direction if more pupils in the upper group than the lower group get the correct item. The discriminating power of a test item refers to the degree to which it discriminates between pupils with high and low achievement. Formula given by Groundlund and

Linn (1990) was used to calculate discriminative power. Following table contains item discrimination (D value) and item difficulty (P value) for each test item:

Table 3.4 Item Analysis Values for Cognitive Ability Test for Science (CATS)

Item No.	Item Discrimination (D)	Item Difficulty (P)
1	0.35	78.24
2	0.88	29.41
3	0.58	18.24
4	-1.11	10.59
5	0.12	10.00
6	0.35	40.00
7	0.88	33.53
8	0.48	34.12
9	0.61	38.82
10	-0.03	34.71
11	0.18	19.41
12	0.67	38.82
13	0.48	63.53
14	0.67	52.94
15	-0.10	47.06
16	0.38	58.24
17	0.06	41.18
18	0.44	48.24
19	0.78	28.82
20	0.78	27.06
21	0.73	38.82
22	0.97	54.71
23	0.67	21.18
24	0.65	50.59
25	0.91	64.71
26	0.64	64.12
27	0.90	30.00
28	0.10	34.71
29	0.95	35.88
30	0.40	20.59
31	0.33	74.71
32	0.04	31.18
33	-0.50	4.71
34	0.32	29.41
35	0.62	52.94

Item No.	Item Discrimination (D)	Item Difficulty (P)
36	-0.26	31.18
37	0.84	18.24
38	0.97	41.18
39	0.00	37.65
40	0.79	42.94
41	0.88	37.65
42	0.88	56.47
43	1.00	30.59
44	0.74	42.94
45	0.38	43.53
46	0.91	32.35
47	0.18	52.94
48	0.65	64.71
49	0.15	24.12
50	0.09	27.06
51	0.57	51.18
52	0.67	31.76
53	0.72	45.88
54	0.24	57.65
55	0.27	17.65
56	0.58	52.94
57	0.14	32.94
58	0.47	42.94
59	0.04	26.47
60	0.35	40.00
61	0.45	50.00
62	0.45	28.82
63	0.69	28.82
64	0.85	47.06
65	0.22	63.53
66	0.48	32.94
67	0.45	47.06
68	0.19	63.53
69	0.60	47.06
70	0.47	44.71

Item No.	Item Discrimination (D)	Item Difficulty (P)
71	-0.28	38.24
72	0.49	15.29
73	-0.25	28.24
74	0.52	71.76
75	0.62	54.71
76	0.91	38.82
77	0.33	39.41
78	0.95	47.06
79	-0.10	37.06
80	-0.20	28.82
81	-0.13	27.65
82	0.19	24.71
83	0.39	62.94
84	0.59	20.00
85	0.63	56.47
86	0.92	28.24
87	0.90	60.00
88	1.13	18.82
89	-0.44	21.18
90	0.49	40.59
91	1.21	35.88
92	0.91	45.29
93	0.59	30.00
94	0.52	31.76
95	-0.21	22.35
96	0.76	32.35
97	0.46	38.24
98	0.77	30.59
99	0.29	28.82
100	0.33	53.53
101	0.68	64.12
102	0.78	46.47
103	-1.41	15.88
104	0.87	45.88
105	0.18	25.88

Item No.	Item Discrimination (D)	Item Difficulty (P)
106	0.61	52.35
107	0.99	51.18
108	0.23	46.47
109	0.49	40.59
110	0.32	29.41
111	0.90	51.18
112	0.85	47.06
113	0.60	62.35
114	0.17	54.12
115	0.34	24.12
116	0.52	38.24
117	0.33	74.71
118	0.62	35.88
119	-0.03	34.71
120	0.43	35.88
121	0.67	17.65
122	0.49	26.47
123	0.41	45.88
124	0.69	39.41
125	-0.53	22.35
126	0.77	22.94
127	0.81	45.29
128	0.48	17.06
129	0.43	27.06
130	0.21	27.65
131	1.08	45.88
132	0.83	58.24
133	0.65	36.47
134	0.82	51.76
135	0.64	71.18
136	0.55	19.41
137	0.00	28.24
138	0.57	59.41
139	0.61	52.35
140	0.29	32.94

Item No.	Item Discrimination (D)	Item Difficulty (P)
141	-0.08	28.24
142	0.04	33.53
143	0.50	28.24
144	-0.42	31.18
145	0.41	42.94
146	-0.29	37.06
147	0.68	44.71
148	0.88	50.59
149	0.42	31.18
150	0.77	65.29
151	0.63	20.59
152	-0.09	25.88
153	0.86	47.65
154	1.03	51.18
155	1.03	38.82
156	1.18	45.88
157	0.19	37.65
158	0.69	28.82
159	0.86	47.65
160	0.62	61.18
161	0.00	32.94
162	0.86	43.53
163	0.69	35.88
164	-0.14	40.59
165	0.77	55.29
166	0.13	18.82
167	1.10	39.41
168	0.97	36.47
169	0.18	33.53
170	1.18	40.00
171	1.07	55.88
172	1.04	56.47
173	0.22	31.76
174	0.43	30.00
175	0.40	29.41

Item No.	Item Discrimination (D)	Item Difficulty (P)
176	0.91	38.82
177	0.92	50.00
178	-0.63	22.35
179	0.59	60.00
180	0.58	26.47
181	-1.09	12.94
182	0.88	58.82
183	0.30	23.53
184	0.63	41.18
185	0.67	28.24
186	0.64	32.94
187	0.36	45.88
188	0.97	41.18
189	0.29	24.71
190	0.32	22.35
191	1.07	17.65
192	0.51	30.00

→ From the calculated item difficulty it was concluded that lower the difficulty value, higher was the difficulty.

→ The test items which had discrimination value less than 0.1 were discarded from the final draft of CATS. Therefore, 30 such items were removed from the final version of the test.

3.5.6 Validity, Reliability and Central Tendencies

The researcher ensured content validity of the Test on cognitive abilities during the tool validation phase. Experts' comments and suggestions were taken into consideration while modifying the tool. In this way, the tool was content validated. Reliability of the test was established using KR 21 formula and split-half reliability (See Appendix E for raw data for Split half reliability coefficient). Reliability was calculated using the KR 21 formula given by Gay and Airasan (1999).

→ The mean score for the cognitive ability test was found to be 73. 67. The mean score for boys was found to be 73.58 and for girls was 73.67.

→ Median was found to be 71.5.

→ Mode was found to be 69.

→ The value of standard deviation was found to be 17.10.

→ The value of KR 21reliability was found to be 0.8492.

→ Split half reliability coefficient was found to be 0.8571.

3.5.7. Final administration of the test

The final draft of CATS contained 162 test items. The test items were of Remember, Understand, Apply, Analyze and Evaluate levels of Bloom's revised taxonomy (2001). The final draft of the test was prepared in four formats by shuffling the test items numbers. The tool was given four codes A, B, C and D. To give an instance, question number 1 in the paper set A was at question number 40 in paper set B, 50 in paper set C and 34 in paper set D. The order of the test items was changed for reducing the interaction among the students and controlling cheating and copying of the correct answers. The finalized draft of CATS was administered on the selected sample of class IX students of Kachchh district. The following table depicts concepts-wise and level-wise specifications of the final draft of CATS (Appendices F & G).

Table 3.5: Blue print for the final draft of CATS

No.	Concepts	Remember	Understand	Apply	Analyze	Evaluate	Total
1	Elements, Compounds, mixtures and molecular structure	1	1	3		2	
2	Separation of substances		2		2		
3	Fossil fuels	3	1	1		1	
4	Classification of matter		2	2	1		
5	Air and preparation of gases	5	3	1	1		
6	Metal - non metal	3	1	2			
7	Combustion	6	1	2			
8	Manmade material	3	2	1	1		
		21	**13**	**12**	**5**	**3**	**54**
1	Magnetism	1	1				
2	Simple machine	2		1		1	
3	Measurement	1	2	2			
4	Modes of heat transfer	1	3		1	1	
5	Energy		1	3			
6	Our solar system	1	1	1			
7	Laws of light	2	1	1	1	1	
8	Curved mirrors and reflectors	1	2				
9	Motion, force and speed	2	1	1		1	
10	Air pressure	3	1	1	1		
11	Electricity	2	3		1		
12	Sound	1	1	1	1		
		17	**17**	**11**	**5**	**4**	**54**
1	Water	3	2		2	1	
2	Animal kingdom and its survival	4	1		1	1	
3	Organ system of human body (Human organ system)	16	2	1			
4	Life cycle of a seed	2	3	1	2		
5	Agricultural practices	1	1				

6	Cell and microorganism	3					
7	Constituents of diet		1				
8	Changes around us			1		1	
9	Environmental equilibrium	2	1	1			
		31	**11**	**4**	**5**	**3**	**54**
	Grand Total	69	41	27	15	10	162

3.6 CONSTRUCTION OF CREATIVITY TEST FOR SCIENCE (CTS)

3.6.1. Content analysis

The researcher analysed the content of the science and technology textbooks of class six to class eight designed by Gujarat State Board of School Textbooks (GSBST). Researcher referred the content of these textbooks for the preparation of the test.

3.6.2. Construction of items

Based on analyzed content of science and technology textbooks researcher constructed test items using action verbs suitable for Creation level of cognitive domain given by Anderson et. al. (2001). The test contained divergent questions. Following table presents the specifications of the test items (Appendices C & D):

Table 3.6: Item pool for Creativity Test for Science (CTS)

Concepts	**Create level questions**
Chemistry	2
Physics	5
Biology	4
Total	**11**

3.6.3. Experts' validation

The item pool of CTS was sent to experts of science and technology subject. The experts were either working as a science teacher in secondary/higher secondary school or assistant professor of science method in teacher education institutes. The minimum qualification of the experts was M. Sc., B.Ed. However, some experts had the qualification M. Sc., M. Ed. while majority of them had earned a Ph. D. in Education too.

1. The instruction part given for each question.

2. The coherence between instruction and the item.
3. The language used in the preparation of items.

A prominent comment received from the experts was to reduce the number of questions in the CTS and provide maximum time to students for responding. This would reduce the burden of attempting questions on the students.

3.6.4. Pilot study

The constructed test was administered on a group of 13 students other than sample to examine it from language aspect and unambiguity of items. It was noted that

- None of the students attempted all the 11 questions of Create level.
- Students preferred those questions which required written responses over the questions requiring to draw or design.
- Additionally, attempting all the 11 Create level questions consumed a lot of time of students and hence caused boredom among them.

3.6.5. Final administration of the test

The constructed test was finally administered on the selected sample of class IX students of Kachchh district. The final tool contained 3 Create level questions; 1 from each content area that is chemistry, physics and biology. Questions of Chemistry and Biology required written responses whereas that of physics required response in drawing (Appendices H & I). There was no any time limit set for the students to write/draw their responses.

3.7 PROCEDURE FOR DATA COLLECTION

The researcher sought permission from the District Education Office (DEO) of Kachchh district. A forwarding letter addressed to the principals was prepared and assurance was given that data collected would be used for research purpose only and would be kept strictly confidential. The data was collected personally by the researcher through administration of the tool. Time given to students to write their responses was 150 minutes. Students were instructed to fill primary details such as their names, school names, class division, gender and paper set code before they started attempting the questions. Following instructions were given to students on administration of the test:

- Attempting all the questions is compulsory.
- Each question has only one correct answer.
- Write the option of the correct answer in front of the question number.
- There is no negative marking for incorrect answer.
- Each correct answer carries one mark.
- Do not make any marks in the question paper.
- Return the question paper on completion of the test.

3.8 DATA ANALYSIS

The data obtained from CATS were quantitative in nature. Since, present study was a normative survey, mean, median, mode and standard deviation were established as norms for the present study. Students' total scores in CATS were converted into interval scale with the help of Microsoft Excel. The sampling technique employed was probability sampling and equal variances were assumed for the present study. Levene's Test for Equality of Variances was employed to test equality of variances. There were three categorical variables namely, gender, medium of instruction and type of school. Therefore, Factorial designs of Analysis of Variance (ANOVA) was employed for testing of hypotheses. For comparing means of variables having more than two levels, Duncan's Multiple Range Test was employed. Additionally, the relationship between students' score in CATS and academic achievement in science was studies with the help of Pearson Product Moment correlation.

The data obtained from CTS was analysed by content analysis. The analysed content was presented in the form of description. The results of data analysis and the interpretation are presented in chapter four.