

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

An outline of the research techniques employed in the study is given in this chapter. The research design or structure includes strategy and methodology. Any research project's validity and generalizability are based on a well-thought-out plan and technique. This study's primary objective was to enhance academic achievement and reduce cognitive load among students in the science subject. This chapter is split into two sections. Section I and Section II. The Intervention program based on constructivist strategies (CPI) was developed through several steps outlined in the first Section. These steps included the identification of content and chapter bifurcation. The second section goes into the specific steps involved in the research process. It covers the population, sampling technique, sample, tools, data gathering process, and data analysis methods. The researcher provides the rationale for selecting the research design used in this study. The methods for carrying out this analysis and the instruments used to gather the data are also described. The researcher also discusses the methods utilized to interpret the data.

3.1 SECTION 1: PROGRAMME

This section presents a detailed overview of the programme development. The intervention programme designed for secondary students was structured in a systematic and organized manner, with its content designed to the Cognitive level appropriate for this age group. The researcher has considered the cognitive abilities of secondary students and the factors that reduce the cognitive load during the programme development. The intervention programme was thoughtfully designed to align with the content of the NCERT textbook to ensure relevance, a logical progression of topics, appropriate terminology, and alignment with the student's cognitive capacity. In the lesson plan, both theoretical and practical components were included. The intervention programme was developed in line with the prior knowledge of learners and the constraints of classroom time. Subtopics and activities of the intervention programme were selected as straightforward yet challenging enough to encourage students to extend their understanding of concepts. The development of the intervention programme includes several phases as follows:

3.1.1 DEVELOPMENT OF THE INTERVENTION PROGRAMME

In this section, the researcher described the phases of the development of the intervention programme. In this intervention programme, the researcher tried to make an intervention programme with age-appropriate norms and the cognitive level of secondary students. For the development of the intervention programme, the first step was the selection of content from the NCERT science textbook. The second step was the selection of constructivist strategies through which chosen content can be taught. The third step was the preparation of the structure of the intervention programme. For the implementation of the intervention programme, the researcher developed the lesson plans according to the NCERT-prescribed format.

Table 3.1: Phases of Development of the Intervention Programme

Phase No.	Phase Name
Phase 1	Selection of Content
Phase 2	Selection of the Constructivist Strategies
Phase 3	Structure of the Intervention Programme

3.1.1.1 Phage I: Selection of Content

Before developing the intervention programme, the researcher went through the science curriculum of Class 9th of the Gujarat Secondary and Higher Secondary Education Board (GSHSEB). All topics were selected for the development of the programme. The researcher used the NCERT textbook and the Diksha programme to select the activities appropriate to the content. The content selection and activities selection were done with the help of subject and pedagogy expert teachers at the school level.

Table 3.2: Synoptic View of the Topic Taken for Intervention Programme Development

Sr. No.	Chapter	Topic
1	Chapter 1 Matter in Our Surroundings	Physical Nature of Matter
		Characteristics of Particles of Matter
		States of Matter
		Can Matter Change Its State?
		Effect of Change of Pressure on Matter
		Effect of Change of Temperature on Matter



		Evaporation
2	Chapter 2 Is Matter Around Us Pure?	What is Mixture
		Solution
		Suspension
		Colloidal Solution
		Physical Change and Chemical Change
		Pure Substance
		Mixture
		Numerical
3	Chapter 5 Fundamental Unit of Life	What are Living Organisms Made Up of?
		What is a Cell Made Up of? What is the Structural Organization of the Cell?
		Plasma Membrane and Cell Membrane
		Cell Wall
		Nucleus
		Cytoplasm
		Cell Organelles <ul style="list-style-type: none"> • Endoplasmic Reticulum • Golgi Apparatus • Lysosomes • Mitochondria • Plastids • Vacuoles
		Cell Division
4	Chapter 7 Motion	Motion
		Measuring the Rate of Motion
		Rate of Change of Velocity
		Graphical Representation of Motion
		Equation of Motion
		Uniform Circular Motion
		Numerical
5	Chapter 8 Force and Laws of Motion	Balanced and Unbalanced Forces
		First Law of Motion
		Inertia and Mass
		Second Law of Motion
		Third Law of Motion
		Numerical
6	Chapter 9 Gravitation	Gravitation
		Free Fall
		Mass
		Weight
		Thrust and Pressure
		Archimedes' Principle

		Numerical
7	Chapter 12 Improvement in Food Resources	Improvement in Crop Yield Animal Husbandry

3.1.1.1.1 Synoptic View of Theory and Activities of the Chapters

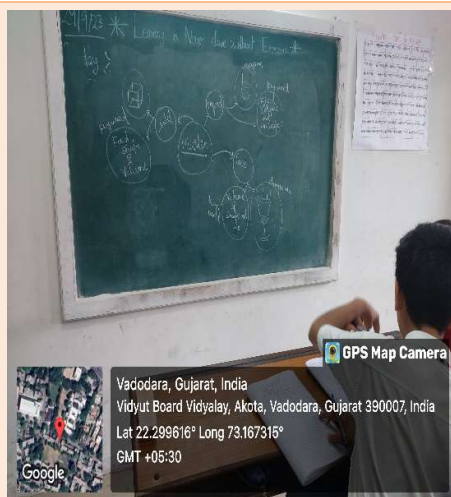
This section presents a brief description of the topic with activities that were taken during the course of the development of the intervention programme.

Table 3.3: A Brief Description of Topics with Their Subtopics and Activities in the Intervention Programme

Chapter 1: Matter in Our Surroundings	
<p style="text-align: center;">Class No. 1</p> <ul style="list-style-type: none"> ➤ Time Duration: 30 Min. ➤ Topic Covered: Physical Nature of Matter ➤ Material: Beaker, KMnO_4, Water ➤ Activity: Demonstration, Discussion ➤ Subtopic Covered: <ul style="list-style-type: none"> • Matter is made up of Particles • How Small are these particles of matter? 	
<p style="text-align: center;">Class No. 2</p> <ul style="list-style-type: none"> ➤ Time Duration: 30 Min. ➤ Topic Covered: Characteristics of Particles of Matter ➤ Material: Beaker, Ink, KMnO_4, Salt, Water ➤ Activity: Demonstration, Discussion ➤ Subtopic Covered: <ul style="list-style-type: none"> • Particles of Matter: <ul style="list-style-type: none"> ○ have space between them ○ are continuously moving ○ attract each other 	

Class No. 3

- **Time Duration:** 30 Min.
- **Topic Covered:** State of Matter
- **Material:** Beaker, Water, Bottle
- **Activity:** Demonstration, Discussion
- **Subtopic Covered:**
 - Solid State
 - Liquid State
 - Gaseous State



Class No. 4

- **Time Duration:** 30 Min.
- **Topic Covered:** Can matter change its state?
- **Material:** Camphor, Spoon
- **Activity:** Demonstration, Discussion
- **Subtopic Covered:**
 - Boiling Point
 - Melting Point
 - Latent Heat
 - Sublimation



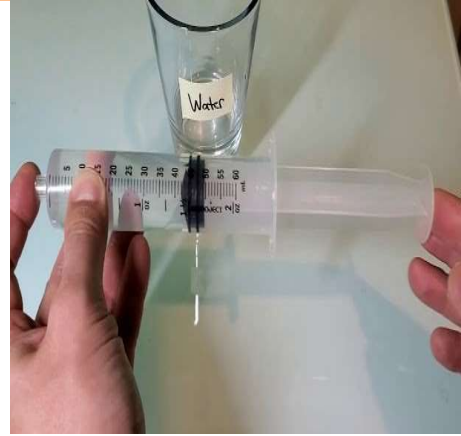
Class No. 5

- **Time Duration:** 30 Min.
- **Topic Covered:** Can matter change its state?
- **Material:** boiling water
- **Activity:** Demonstration, Discussion
- **Subtopic Covered:**
 - Deposition
 - Condensation
 - Vaporization



Class No. 6

- **Time Duration:** 30 Min.
- **Topic Covered:** Effect of change of pressure and temperature on matter
- **Material:** Siring and water
- **Activity:** Demonstration, problem solving
- **Subtopic Covered:**
 - Effect of pressure on matter



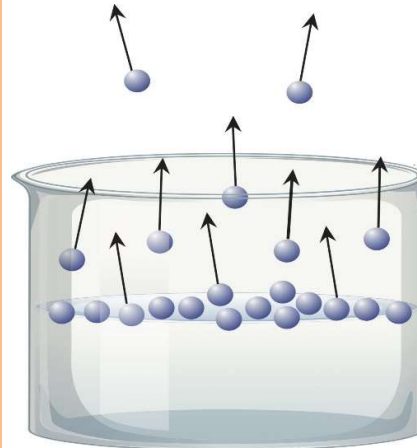
Class No. 7

- **Time Duration:** 30 Min.
- **Topic Covered:** Effect of change of temperature on matter
- **Material:** Boiling water
- **Activity:** Demonstration, problem solving
- **Subtopic Covered:**
 - Effect of temperature on matter



Class No. 8

- **Time Duration:** 30 Min.
- **Topic Covered:** Evaporation
- **Activity:** Demonstration, problem solving
- **Subtopic Covered:**
 - Factor affecting evaporation
 - How does evaporation cause



Chapter 2: Is Matter Around Us Pure?

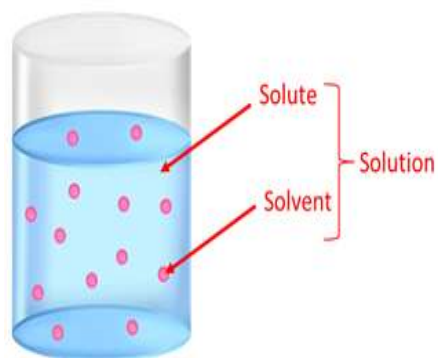
Class No. 1

- **Time Duration:** 30 Min.
- **Topic Covered:** What is a Mixture?
- **Material:** salt and sand, soil
- **Activity:** Demonstration, problem-solving
- **Subtopic Covered:**
 - What is a Mixture?
 - Types of Mixture



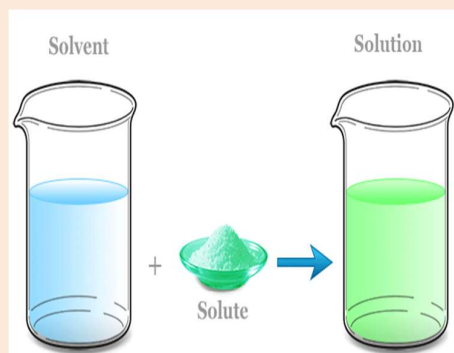
Class No. 2

- **Time Duration:** 30 Min.
- **Topic Covered:** Solution
- **Material:** salt and water
- **Activity:** Demonstration, problem-solving.
- **Subtopic Covered:**
 - What is Solution?
 - Properties of Solution.



Class No. 3

- **Time Duration:** 30 Min.
- **Topic Covered:** Solution
- **Activity:** Demonstration, problem-solving.
- **Subtopic Covered:**
 - Concentration of the solution.
 - Numerical.



Class No. 4

- **Time Duration:** 30 Min.
- **Topic Covered:** Suspension
- **Material:** Soil and Water, Glass,
- **Activity:** Demonstration, problem-solving.
- **Subtopic Covered:**
 - What is suspension?
 - Properties of suspension.



Class No. 5

- **Time Duration:** 30 Min.
- **Topic Covered:** Colloidal Solution
- **Activity:** Demonstration, problem-solving.
- **Subtopic Covered:**
 - What is colloidal solution?
 - Properties of colloidal solution.



Class No. 6

- **Time Duration:** 30 Min.
- **Topic Covered:** Colloidal Solution
- **Activity:** Demonstration, problem-solving.
- **Subtopic Covered:**
 - Difference between colloid, suspension and solution.



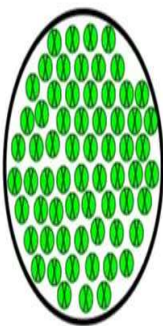
Class No. 7

- **Time Duration:** 30 Min.
- **Topic Covered:** Physical Change and Chemical Change
- **Activity:** Demonstration, problem-solving.
- **Subtopic Covered:**
 - Physical Change.
 - Chemical Change.

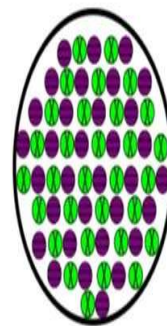


Class No. 8

- **Time Duration:** 30 Min.
- **Topic Covered:** Types of Pure Substance
- **Material:** Coin
- **Activity:** Demonstration, problem-solving.
- **Subtopic Covered:**
 - Elements
 - Metal and Non-Metal
 - Properties of metal and non-metal



Element



Compound

Class No. 9

- **Time Duration:** 30 Min.
- **Topic Covered:** Types of Pure Substance
- **Material:** Coin
- **Activity:** Demonstration, problem-solving.
- **Subtopic Covered:**
 - Properties of metal and non-metal
 - Compound



Class No. 10

- **Time Duration:** 30 Min.
- **Topic Covered:** Mixture
- **Material:** soil and sand
- **Activity:** Demonstration, problem-solving.
- **Subtopic Covered:**
 - What is Mixture?
 - Difference between mixture and compound.

Iron filings, salt and sand



Class No. 11

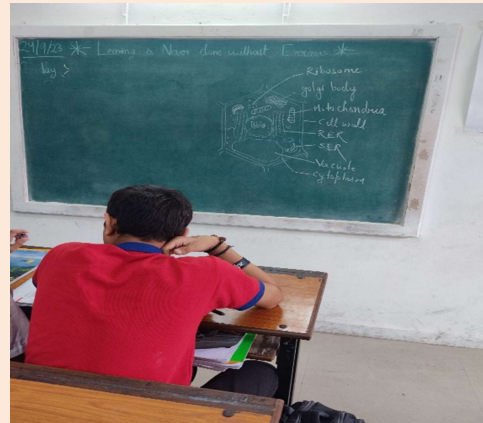
- **Time Duration:** 30 Min.
- **Topic Covered:** Mixture
- **Activity:** Problem-solving.
- **Subtopic Covered:**
 - Numerical



Chapter 5 The Fundamental Unit of Life

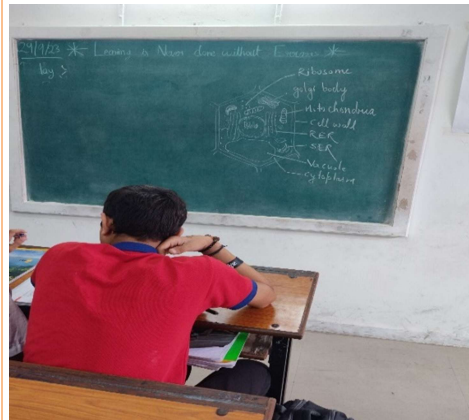
Class No. 1

- **Time Duration:** 30 Min.
- **Topic Covered:** Cell
- **Material:**
- **Activity:** Discussion and Questioning.
- **Subtopic Covered:**
 - What is Cell
 - Types of Cells.



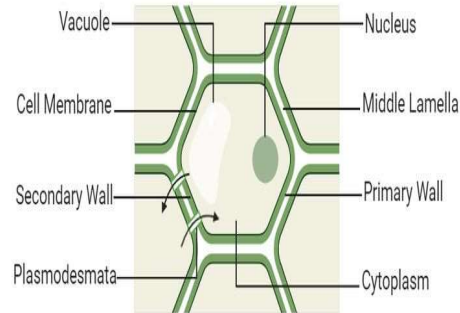
Class No. 2

- **Time Duration:** 30 Min.
- **Topic Covered:** Plasma membrane
- **Material:**
- **Activity:** Problem-solving, Brainstorming.
- **Subtopic Covered:**
 - Plasma Membrane
 - Function of Plasma Membrane



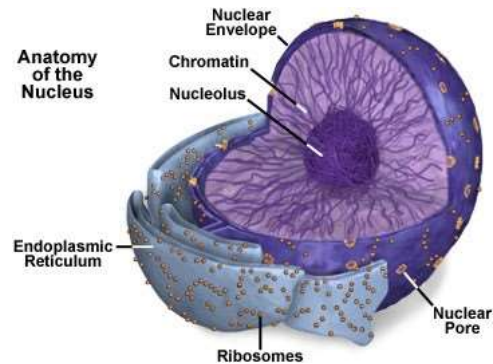
Class No. 3

- **Time Duration:** 30 Min.
- **Topic Covered:** Cell Wall
- **Activity:** Problem-solving.
- **Subtopic Covered:**
 - Cell wall
 - Function of Cell wall



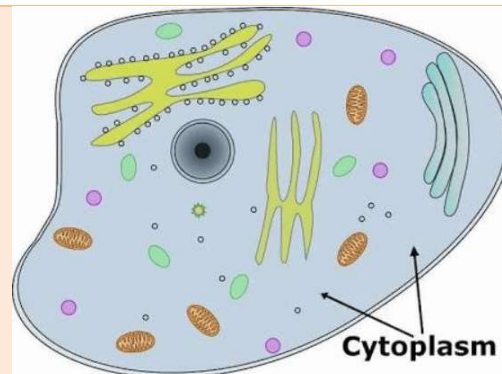
Class No. 4

- **Time Duration:** 30 Min.
- **Topic Covered:** Nucleus
- **Activity:** Problem-solving, Brainstorming.
- **Subtopic Covered:**
 - Structure of Nucleus
 - Function of Nucleus



Class No. 5

- **Time Duration:** 30 Min.
- **Topic Covered:** Cytoplasm
- **Activity:** Problem-solving, Brainstorming.
- **Subtopic Covered:**
 - What is Cytoplasm?
 - Function of Cytoplasm



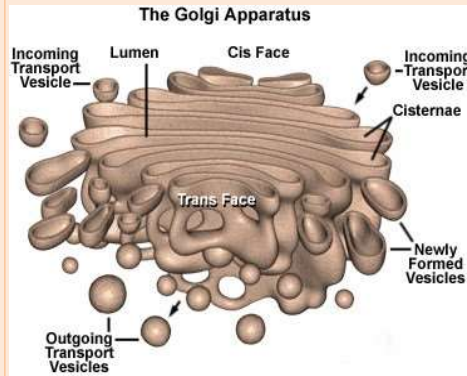
Class No.- 6

- **Time Duration:** 30 Min.
- **Topic Covered:** Endoplasmic Reticulum
- **Activity:** Problem-solving, Brainstorming.
- **Subtopic Covered:**
 - Structure of Endoplasmic Reticulum
 - Function of Endoplasmic Reticulum
- Function of Nucleus



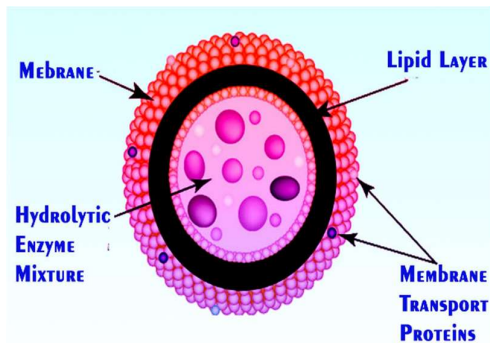
Class No. 7

- **Time Duration:** 30 Min.
- **Topic Covered:** Golgi Body
- **Material:**
- **Activity:** Problem-solving, Brainstorming.
- **Subtopic Covered:**
 - Structure of Golgi-Apparatus
 - Function of Golgi-Apparatus



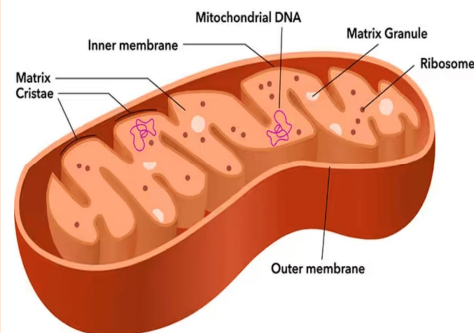
Class No. 8

- **Time Duration:** 30 Min.
- **Topic Covered:** Lysosome
- **Activity:** Problem-solving, Brainstorming.
- **Subtopic Covered:**
 - Structure of Lysosome
 - Function of Lysosome



Class No. 9

- **Time Duration:** 30 Min.
- **Topic Covered:** Mitochondria
- **Activity:** Problem-solving, Brainstorming.
- **Subtopic Covered:**
 - Structure of Mitochondria
 - Function of Mitochondria



Class No. 10

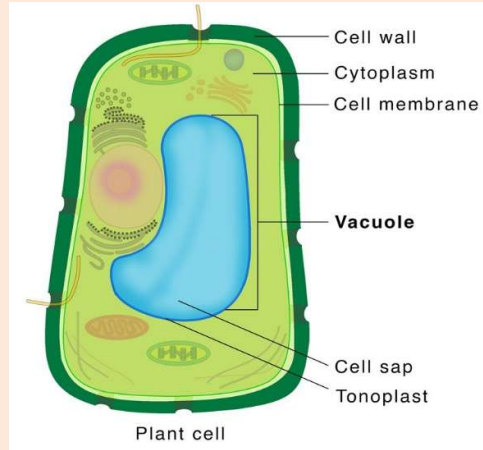
- **Time Duration:** 30 Min.
- **Topic Covered:** Plastids
- **Material:** Different types of seeds
- **Activity:** Discussion, Problem-solving, Brainstorming.
- **Subtopic Covered:**
 - Structure of Plastids
 - Types of Plastids
 - Function of Plastids



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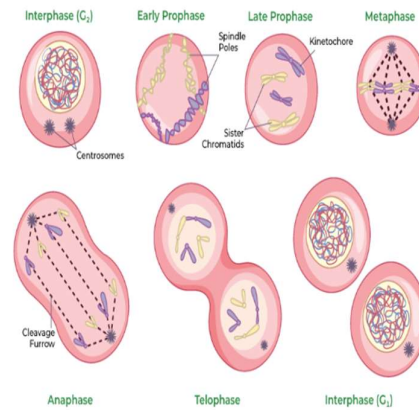
Class No. 11

- **Time Duration:** 30 Min.
- **Topic Covered:** Vacuole
- **Activity:** Problem-solving, Brainstorming.
- **Subtopic Covered:**
 - Structure of Vacuole
 - Function of Vacuole



Class No. 12

- **Time Duration:** 30 Min.
- **Topic Covered:** Cell Division
- **Activity:** Brainstorming.
- **Subtopic Covered:**
 - What is Cell Division
 - Types of Cell Division
 - Mitosis
 - Meiosis
 - Function of Cell Division



Chapter 7: Motion

Class No. 1

- **Time Duration:** 30 Min.
- **Topic Covered:** Motion
- **Activity:** Brainstorming, discussion.
- **Subtopic Covered:**
 - What is Motion
 - Uniform and non-uniform motion



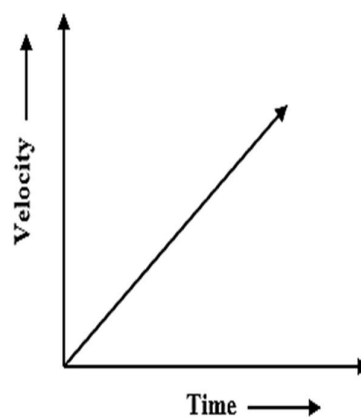
Class No. 2

- **Time Duration:** 30 Min.
- **Topic Covered:** Measuring the rate of motion
- **Activity:** Problem-Solving,
- **Subtopic Covered:**
 - Speed
 - Velocity
 - Displacement
 - Numerical



Class No. 3

- **Time Duration:** 30 Min.
- **Topic Covered:** Rate of change in Velocity
- **Activity:** Problem Solving.
- **Subtopic Covered:**
 - Speed with Direction
 - Accelerated Motion
 - Numerical



Class No. 4

- **Time Duration:** 30 Min.
- **Topic Covered:** Graphical representation of Motion
- **Activity:** Problem-Solving.
- **Subtopic Covered:**
 - Distance time graph
 - Numerical



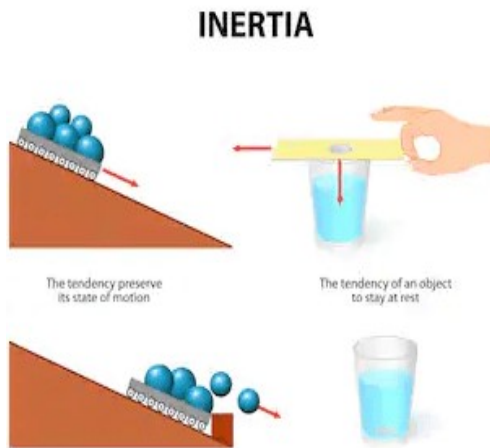
Class No. 5

- **Time Duration:** 30 Min.
- **Topic Covered:** Graphical representation of Motion
- **Material:**
- **Activity:** Problem-Solving.
- **Subtopic Covered:**
 - Velocity-time graph
 - Numerical



Class No. 6

- **Time Duration:** 30 Min.
- **Topic Covered:** Equation of Motion
- **Activity:** Problem-Solving, Discussion.
- **Subtopic Covered:**
 - First law of Motion
 - Second law of Motion
 - Third law of Motion



Class No. 7

- **Time Duration:** 30 Min.
- **Topic Covered:** Circular Motion
- **Material:** Thread and Ball
- **Activity:** Brainstorming and Problem Solving.
- **Subtopic Covered:**
 - Centripetal and centrifugal force
 - Uniform circular motion
 - Mathematical Derivation
 - Benefits of Circular motion like Celestial Movement



Class No. 8

- **Time Duration:** 30 Min.
- **Topic Covered:** Motion
- **Activity:** Problem-Solving.
- **Subtopic Covered:**
 - Numerical based on the concept which taught in the present chapter (Exercise)

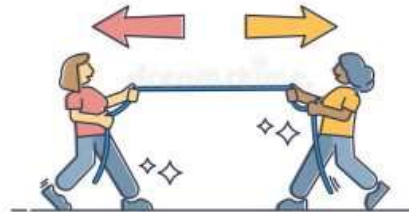


Chapter 8: Force and Laws of Motion

Class No. 1

- **Time Duration:** 30 Min.
- **Topic Covered:** Force
- **Material:** Thread, Ball
- **Activity:** Problem-Solving.
- **Subtopic Covered:**
 - What is force
 - Balanced and unbalanced force

BALANCED FORCES



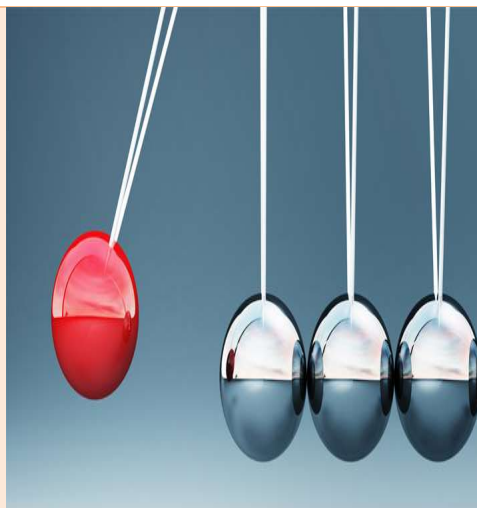
Class No. 2

- **Time Duration:** 30 Min.
- **Topic Covered:** Laws of Motion
- **Material:** Balls, Duster, Books
- **Activity:** Problem-Solving.
- **Subtopic Covered:**
 - Mass
 - Inertia
 - First law of motion



Class No. 3

- **Time Duration:** 30 Min.
- **Topic Covered:** Laws of Motion
- **Material:** Two Balls
- **Activity:** Problem-Solving.
- **Subtopic Covered:**
 - Momentum
 - Second law of motion
 - Mathematical formulation of the Second law of motion



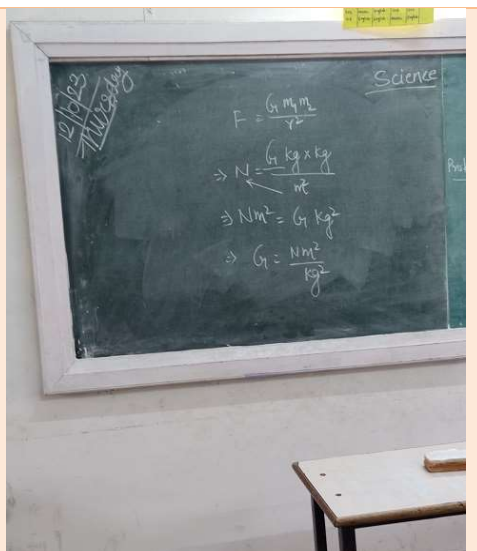
Class No. 4

- **Time Duration:** 30 Min.
- **Topic Covered:** Laws of Motion
- **Material:** Two Balls
- **Activity:** Problem-Solving, discussion.
- **Subtopic Covered:**
 - Third law of motion
 - Numerical



Class No. 5

- **Time Duration:** 30 Min.
- **Topic Covered:** Force and Laws of Motion
- **Material:** Thread, Books,
- **Activity:** Problem-Solving.
- **Subtopic Covered:**
 - Numerical based on the chapter



Chapter 9 Gravitation

Class No. 1

- **Time Duration:** 30 Min.
- **Topic Covered:** Gravitational Force
- **Material:** Thread, Balls
- **Activity:** Brainstorming, discussion.
- **Subtopic Covered:**
 - Gravitational force
 - Universal nature of gravitational force
 - Derivation of gravitational force



Class No. 2

- **Time Duration:** 30 Min.
- **Topic Covered:** Gravitational Force
- **Material:** Thread, Balls
- **Activity:** Brainstorming, discussion.
- **Subtopic Covered:**
 - Importance of gravitational force
 - Free Fall



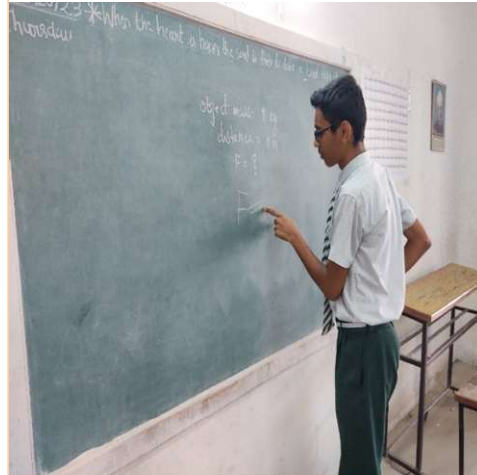
Class No. 3

- **Time Duration:** 30 Min.
- **Topic Covered:** Gravitational Force
- **Material:** Thread, Balls
- **Activity:** Problem-solving, discussion.
- **Subtopic Covered:**
 - Calculation of gravitational force (g)
 - Motion under the influence of g



Class No. 4

- **Time Duration:** 30 Min.
- **Topic Covered:** Mass and Weight
- **Material:** Books, duster
- **Activity:** Problem-solving, discussion.
- **Subtopic Covered:**
 - Mass and weight
 - Weight of an object on moon



Class No. 5

- **Time Duration:** 30 Min.
- **Topic Covered:** Thrust and Pressure
- **Material:** Nails
- **Activity:** Problem-solving, Discussion.
- **Subtopic Covered:**
 - Thrust
 - Pressure
 - Numerical



Class No. 6

- **Time Duration:** 30 Min.
- **Topic Covered:** Pressure in Fluid and Archimedes' Principle
- **Material:** Water and bottle
- **Activity:** Brainsorming, Discussion.
- **Subtopic Covered:**
 - Buoyancy
 - Archimedes' principle
 - Importance of Archimedes' principle



Class No. 7

- **Time Duration:** 30 Min.
- **Topic Covered:** Gravitation
- **Material:**
- **Activity:** Problem-solving,
- **Subtopic Covered:**
 - Numerical based on the concept which taught in the chapter (Exercise)



Chapter 12: Improvement in Food Resources

Class No. 1

- **Time Duration:** 30 Min.
- **Topic Covered:** Food Resource
- **Activity:** Discussion, Brainstorming.
- **Subtopic Covered:**
 - Resource and Food Resources
 - Improvement in Crop Yield



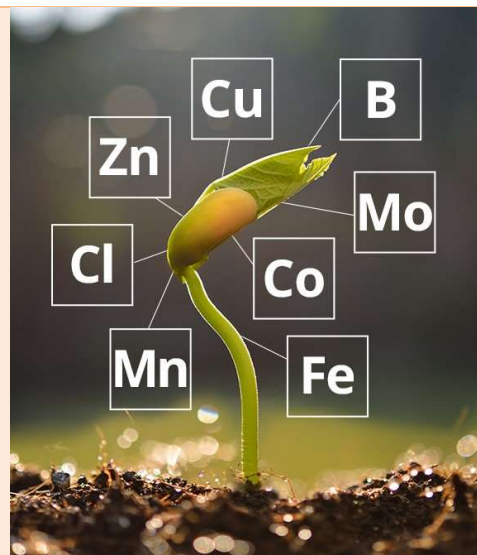
Class No. 2

- **Time Duration:** 30 Min.
- **Topic Covered:** Improvement in crop yield
- **Activity:** Discussion, Brainstorming.
- **Subtopic Covered:**
 - Crop variety improvement
 - Crossing
 - Hybridization



Class No. 3

- **Time Duration:** 30 Min.
- **Topic Covered:** Improvement in crop yield
- **Activity:** Discussion, Problem-solving.
- **Subtopic Covered:**
 - Crop production management
 - Nutrient
 - Macronutrient
 - Micronutrient



Class No. 4

- **Time Duration:** 30 Min.
- **Topic Covered:** Improvement in crop yield
- **Activity:** Discussion, Problem-solving.
- **Subtopic Covered:**
 - Manure
 - Types of manure
 - Fertilizers
 - Irrigation



Class No. 5

- **Time Duration:** 30 Min.
- **Topic Covered:** Improvement in crop yield
- **Activity:** Discussion, Problem-solving.
- **Subtopic Covered:**
 - Manure, & Fertilizers
 - Types of manure
 - Nitrogen Fixation
 - Irrigation



Class No. 6

- **Time Duration:** 30 Min.
- **Topic Covered:** Improvement in crop yield
- **Activity:** Discussion, Brainstorming.
- **Subtopic Covered:**
 - Cropping pattern
 - Mixed and Inter Cropping
 - Benefits of cropping pattern



Class No. 7

- **Time Duration:** 30 Min.
- **Topic Covered:** Improvement in crop yield
- **Material:** Infected Leaf
- **Activity:** Problem-solving, Brainstorming.
- **Subtopic Covered:**
 - Crop protection management
 - Weeds and pest
 - Disease
 - Pathogen
 - Storage of grain



Class No. 8

- **Time Duration:** 30 Min.
- **Topic Covered:** Animal Husbandry
- **Activity:** Discussion, Brainstorming.
- **Subtopic Covered:**
 - What is animal husbandry
 - Benefits of Animal husbandry



Class No. 9

- **Time Duration:** 30 Min.
- **Topic Covered:** Animal Husbandry
- **Activity:** Brainstorming.
- **Subtopic Covered:**
 - Cattle forming
 - Breeding
 - Feed of animals
 - Benefits of cattle forming



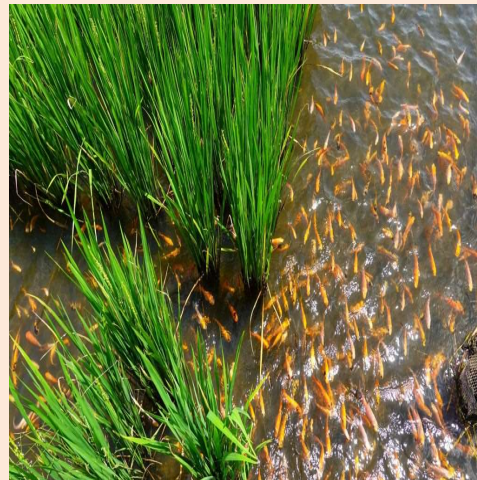
Class No. 10

- **Time Duration:** 30 Min.
- **Topic Covered:** Animal Husbandry
- **Activity:** Brainstorming.
- **Subtopic Covered:**
 - Poultry Forming



Class No. 11

- **Time Duration:** 30 Min.
- **Topic Covered:** Animal Husbandry
- **Activity:** Problem-solving.
- **Subtopic Covered:**
 - Aquaculture, mariculture
 - Fish Production
 - Marine fisheries
 - Inland fisheries



Class No. 12

- **Time Duration:** 30 Min.
- **Topic Covered:** Animal Husbandry
- **Activity:** Brainstorming.
- **Subtopic Covered:**
 - Beekeeping
 - Benefits of beekeeping



3.1.1.2 Phase II: Selection of the Constructivist Strategies

Before selecting strategies, the researcher met with the subject and pedagogy experts of science in different schools and University departments. The researcher reviewed the literature to gain insight into how to make lectures interactive and what constructivist strategies can be incorporated into the lecture.

Table 3.4: Constructivist Strategies Selected for the Intervention Programme

Sr. No.	Name of the Constructivist Strategies Incorporated in the Intervention Programme
1	Brainstorming
2	Problem-solving
3	Mind-map
4	Discussion
5	Questioning

3.1.1.3 Phase III: Structure of the Intervention Programme

The researcher has developed the intervention programme to enhance learning among learners. This intervention programme aims to enhance learning outcomes by reducing the cognitive load among learners. The intervention programme also serves for the completion of the subject by providing scope to the learner for constructing their own knowledge through their prior experiences. This programme helped the

teacher to be more democratic in the classroom. Considering the cognitive load theory, the researcher broke down the topics into small subtopics and tried to incorporate suitable activities in the intervention programme through which learners can find scope for activity during the intervention. A total of sixty-three lesson plans were prepared for seven chapters. Lesson plans varied according to the content of the chapters. The structure of the lesson plans is described below.

3.1.2 FORMAT OF LESSON PLAN

The researcher had developed an intervention programme in the form of a total of sixty-three lesson plans. The intervention programme was made for one semester and covered seven chapters, i.e. Matter in our Surroundings, Is Matter Around Us Pure? Fundamental Units of Life, Motion, Force and Laws of Motion, Gravitation and Improvement in Food Resources. Each lesson plan consisted of information about the topic, class duration, prior knowledge of the learners, specific objectives of the topic that would be taught, selected constructivist strategy during the transaction of the topic and teacher and students' activities. The format of the lesson plan is described below.

Prior Knowledge

This heading deals with learner experiences with which learners come into the classrooms. The lesson plans started with the prior knowledge of the learner. The whole teaching-learning process in the classroom depends in the classroom upon the prior knowledge of the learners. This prior knowledge is the basis of the selection of the content and the learning experiences like pedagogy during the transaction of the specific topic.

Specific objectives or learning outcomes are stated after stating the learners' expected prior knowledge or entry behaviour.

Specific Objective or Learning Outcome After Class

After prior knowledge, the specific objectives stated in the lesson plan describe the learning outcomes of the learners after the topic completion. It showed the behavioural change in the learner. It also helped in the selection of the learning experiences during the intervention. This specific objective was measurable in terms of learning outcomes or achievement. Based on the assessment of specific objectives, it can be said that the objectives of teaching a particular topic were achieved or not.

The main body of the lesson plan is described as teacher and students' activities.

Teacher and Student Activity

To attain the specific objective, the whole teaching-learning activities are organized as teacher and student activities. This represents the topic and subtopics, selected activities, teacher behaviour and students' behaviour during the intervention.

Phase of the Knowledge Construction in the Learner

In this section of the lesson plan phase of the schema formation was described. In students schema constructed in the various phase like disequilibrium, assimilation, accommodation, and equilibrium.

3.2 SECTION II

3.2.1 METHODOLOGY

A quantitative approach was used in the present study. The methodology included the design of the study, variables of the study, population, sample, tools of data collection, procedures of data collection, and data analysis.

3.2.2 DESIGN OF THE STUDY

This study was quasi-experimental in nature. The pre-test and post-test non-equivalent group design (Cresswell, 2008) was used in the proposed study. Best and Kahn (1996)

described, “This design is often used in classroom experiments when experimental and control groups are such naturally assembled groups as intact classes, which may be similar.” The design of the proposed study is presented as follows.

Table 3.5: Design of the Study

Pre-test Post-test Non-Equivalent Control Group Design			
Experimental Group	O ₁	X	O ₂
Control Group	O ₃	C	O ₄
O ₁ and O ₃ = Pre-test		O ₂ and O ₄ = Post-test	
X = Treatment, C = Control (No Treatment)			

3.2.3 VARIABLES OF STUDY

In the present study, the independent variable was the developed intervention program based on the constructivist approach. The dependent variables were the achievement of students in science and the cognitive load of students in the science subject.

Table 3.6: Variables of the Study

Independent Variable	Dependent Variable
Intervention Programme Based on	Achievement
Constructivist Strategies	Cognitive Load

3.2.4 POPULATION

All the standard IX students studying in English Medium Schools that were affiliated with the Gujarat Secondary and Higher Secondary Education Board for the session 2023-24 were considered as the population of the study.

3.2.5 SAMPLE

Two English medium schools affiliated with the Gujarat Secondary and Higher Secondary Education Board were selected purposively from Vadodara city to get the schools for the experimentation of one semester. Out of these two schools, i.e. University Experimental School and Vidyut Board Vidyalaya, the University Experimental School was selected for the control group, and Vidyut Board Vidyalaya was selected for the experimental group. In the University Experimental School, there was one section in which a total of 61 students were enrolled. At the same time, in Vidyut Board Vidyalaya, there were two sections, i.e. A and B, in which 61 and 63 students were enrolled, respectively. All the students of standard IX of the selected schools constituted the sample of the proposed study. Both experimental and control

groups were made equal based on their scores on Raven’s Progressive Matrices. For this purpose, the one-by-one matching technique was applied. A total of 85 students were excluded from the final sample. After exclusion, only 100 students remained in the final sample. The mean of both experimental and control groups was 39.82.

Table 3.7: Number of Participants

Sr. No.	Groups	Number of students	Mean
1	Control Group	50	39.82
2	Experimental Group	50	39.82

3.2.6 TOOLS OF DATA COLLECTION

The following tools were prepared by the researcher and used for data collection.

3.2.6.1 Ravens Progressive Matrices: John C. Raven created this tool in 1936. In this tool, there are five sections with increasing difficulty levels. It was designed to evaluate logical thinking as well as intellectual growth. It helped the researcher to measure adults' IQ from 14 to 65 years old, regardless of their nationality, religion, or other characteristics. The goal is to identify the desired figure both in the answer gap and among the offered choices, forming a pattern that links all the figures together. The Raven Test gets more complex as it goes on, requiring more mental capacity to interpret and assess the questions.

The test receives its name from the abundance of patterns that are offered in the form of a "6×6, 4×4, 3×3, or 2×2 matrix" (Dwivedi, 2023). To accommodate responders with various levels of competence, Matrices are offered in three different formats:

Table 3.8: Types of Ravens Progressive Matrices

Sr. No.	Formats	Used for
1.	Raven’s Standard Progressive Matrices	General population
2.	Raven’s Coloured Progressive Matrices	Children and elderly people
3.	Raven’s Advanced Progressive Matrices	Top 20% of the population

The researcher selected Standard Progressive Matrices for this investigation after noting the characteristics of each Raven's matrix.

The original matrix exam was "Raven's Standard Progressive Matrices (SPM)" test, initially released in 1938. This exam evaluates abstract reasoning and is considered a

nonverbal representation of fluid intelligence. There are sixty multiple-choice questions in all, ranked from easiest to hardest. "This format is meant to examine the test taker's capacity to reason, specifically the educational (meaning-making) component of Spearman's g," according to Orluwene and Emekene (2017). (g is sometimes referred to as general intelligence)." In each test item, the respondents were required to find the missing piece that completes a pattern. The 60 items in the matrices are arranged into five 12-item groups (A, B, C, D, & E). Each item in the matrices is a figure that is missing one of its elements, and it is displayed in black ink on a white backdrop. The test takes about sixty minutes to complete.

3.2.6.2 Internal Consistency of Raven's Standard Progressive Matrices (SPM) test's Dependability

The reliability coefficient of this standardized instrument is 0.96. Numerous studies have been conducted to support the validity of Standard Progressive Matrices (SPM). In the NCS Pearson (2007) report, the internal consistency reliability estimate for the Standard Progressive Matrices (SPM) total raw score was 0.88 in a standardized sample of 793 persons. When a reliability coefficient is interpreted using this reliability estimate, it indicates that the SPM's total raw score has a high degree of internal consistency dependability.

- SPM scores showed reliability in terms of: "a) internal consistency - 0.92; b) split halves - 0.81; c) test-retest - 0.69, which demonstrated significant correlation; and correlation between each item individually and the total score of the tests - 0.69, which demonstrated significant correlation for 59 items" (Al-Bokaia and Al-Subaihib, 2021 as cited in Dwivedi, 2023).

3.2.6.3 Validity

The investigator found numerous studies that supported the validity of Standard Progressive Matrices (SPM).

- Abdel-Khalek (1988) found that among 452 Egyptian university students, the correlation between SPM scores and the Arabic versions of Thurstone's Primary Mental Abilities battery's spatial orientation test (PMA Space), the PMA Inductive Reasoning test (46), and the PMA Verbal test (31), was 0.60.
- Among 288 students of different ages, O'Leary, Rusch, and Guastello (1991) found a correlation between 74 and 84 between SPM scores and Full-Scale IQ scores on the Wechsler Adult Intelligence Scale.
- Chan (quoted in Ree & Carreta, 2002) found that "scores on the Raven's Progressive

Matrices related to participants' judgments of their 'initiative for any task' in a validation study of assessment centers.

- Raven's SPM scores and performance on decision-making tasks show a positive link, according to additional research groups (Gonzalez, Thomas, & Vanyukov, 2005). Watson & Glaser (2006) discovered that, in a subgroup of 129 people from the Watson-Glaser Short Form Manual standardization sample, the revised SPM scores correlate 43 with thinking and reasoning.
- "Scores on the current SPM were 97 percent consistent with scores on the previous SPM in a standardization sample of 793 individuals," citing the NCS Pearson (2007) study.
- Additional proof that the SPM accurately predicts a person's capacity to achieve and retain activities requiring high levels of general mental ability can be found in the SPM Manual (Raven, 2003).
- Al-Bokaia and Al-Subaihib (2021) conducted a study on 414 teenagers from various secondary schools in Amman who were between the ages of fifteen and seventeen. The following conclusions are illustrated in the validity section: Items that are sufficiently challenging and a substantial difference between the top and lowest 15% of scores when chosen from the extremes of the distribution; b) a significant correlation with the School and College Ability Test (SCAT); c) discrimination indexes; and Confirmatory factor analysis (CFA), which guaranteed the theoretical foundation for the items by Spearman's theory of intelligence.

3.2.6.4 Scoring

There were 60 questions in the Raven's Standard Progressive Matrices (SPM) test, and each of the five sets (A–E) comprised a total of 12 questions. Following a comparison of the students' results (out of 60) with the interpretation table, each student in the control and experimental groups was awarded a percentile rank. Thirty students were selected (for one-to-one group matching) from the control and experimental groups after the percentile rank was assigned.

3.2.7 Cognitive load scale: The cognitive load scale was designed to measure students' cognitive burden during the lab equipment learning exercise. The three types of cognitive load measurement are practiced in educational scenarios, i.e. Self-reported assessment, Dual-task measurement, and Physiological measurement. This scale is based on self-reported measurement techniques. This scale is a direct-

subjective technique that allows students to report their stress and difficulty levels during the learning process. The survey was modified from the Hwang, Yang, and Wang (2013) survey scale. The parameters given by Sweller, Van Merriënboer, and Paas (1998) and Paas (1992) served as the main focus of the survey. It consists of three items for "mental effort" and five items for "mental load." It includes statements like "I had to put a lot of effort into answering the questions in this learning activity," "The learning content in this learning activity was difficult for me," and "I need to put a lot of effort into completing the learning tasks or achieving the learning objectives in this learning activity." This is a five-point Likert scale that provides scope to rate their experience from strongly disagree to strongly agree. In the study by Hwang, Yang, and Wang (2013), the Cronbach's alpha values for mental load and mental effort were 0.86 and 0.85, respectively. Chang and Hwang (2018) employed the scale to assess cognitive strain with success.

3.2.7.1 Scoring: In this scale, rating is done on the five-point scale. All items are positive; therefore, strongly disagree is assigned one mark and strongly agree is assigned five marks. This score shows the magnitude of cognitive load. The minimum possible score on the scale is eight marks, and the maximum possible score is forty marks.

3.2.8 Reaction Scale: The reaction scale was prepared to collect data on objective 10 from the students. This reaction scale is a 5-point Likert scale to know the students' opinions on the effectiveness of the developed intervention program. This scale was prepared based on dimensions such as interest, scope for activities, active participation, joyful learning, and attainment of concept.

3.2.8.1 Scoring: This reaction scale consisted of twenty-three questions that were answered from strongly agree to strongly disagree. All items were positive statements; therefore, five marks were assigned to strongly agree, and in this decreasing continuum, one mark was assigned to strongly disagree.

3.2.9 Science Achievement Test: The researcher has prepared an Achievement Test, which served as the tool for data collection. The researcher prepared this test to evaluate the performance of experimental and control groups of students on their Knowledge, Understanding, and Application levels based on Bloom's Taxonomy. The lowest level of Bloom's Taxonomy is knowledge, which is defined as the ability to

recall basic terms, definitions, concepts, and other information from previously learned material (memory level or knowledge level). The next level is comprehension, characterized by organizing, comparing, translating, interpreting, providing a description, and outlining the essential ideas to show that one understands the facts and concepts. The ability to apply learned facts, strategies, and principles in novel or creative ways to solve problems in novel contexts is the focus of Bloom's level III Applying, which comes after Understanding (Yaduvanshi, 2016).

For test construction, the researcher thoroughly studied the whole content of the syllabus of class IX science textbook that was covered in the first semester prescribed by GSHSEB. The purpose of the test was to assess the candidates' performance in relation to knowledge, comprehension, and application levels of the cognitive domain. The Gujarat Secondary and Higher Secondary Board (GSHSEB) suggested the six chapters for the first semester from the class ninth science syllabus, which served as the basis for this achievement test. These lesson plans covered the chapters of the Class IX NCERT (National Council of Education Research and Training) science textbook titled Matters in our Surroundings, Is matter around us pure? The Fundamental Unit of Life, Motion, Force and Laws of Motion, Gravitation, and the Improvement of food resources.

3.2.9.1 Achievement Test Design: After the selection of the chapters and preparation of lesson plans, a design that adheres to the plan was created. Each objective and each chapter was given the appropriate amount of weight according to its content. According to the updated Bloom's taxonomy, the items were created based on the primary objectives in the cognitive domain. The details are provided in the form of a blueprint.

Table 3.9: Blueprint of the Achievement Test

Sr.	Chapter	Knowledge	Understanding	Application		Total (mcq)	Total
				MCQ	Descript		
1	Matter in Our Surroundings	4 (1)	5 (1)	3 (1)	2 (1)	12 (12)	14 (14)
2	Is Matter Around Us Pure?	4 (1)	5 (1)	3 (1)	2 (1)	12 (12)	14 (14)
3	Fundamental Unit of Life	4 (1)	5 (1)	4 (1)	2 (1)	13 (13)	15 (15)
4	Motion	4 (1)	5 (1)	3 (1)	2 (1)	12 (12)	14 (14)

5	Force and Law of Motion	4 (1)	5 (1)	3 (1)	2 (1)	12 (12)	14 (14)
6	Gravitation	4 (1)	5 (1)	3 (1)	2 (1)	12 (12)	14 (14)
7	Improvement in Food Resources	5 (1)	5 (1)	3 (1)	2 (1)	13 (13)	15 (15)
	Total	29 (29)	35 (35)	22 (22)	14 (14)	86 (86)	100 (100)

3.2.9.2 First Draft of Achievement Test: In the first draft, there were 125 multiple-choice questions and 19 descriptive-type questions in the test, covering every topic in the seven chapters titled Matters in our surroundings, Is matter around us pure? The fundamental unit of Life, Motion, Force, and laws of motion, Gravitation, and Improvement in food resources. The researcher constructed this test in two sections: the multiple-choice questions and the descriptive-type questions. The researcher designed these items using the updated three levels of the cognitive domain of Bloom's taxonomy. Items at the knowledge level focused on facts, names, terminology, principles, etc., which were important to remember. Understanding level items address the capacity for interpretation, translation, investigation, example-giving, differentiation, comparison, revision, and summarization. Applying level items strongly emphasized the cognitive processes involved in recognizing and using newly learned knowledge in novel or unfamiliar contexts. Each multiple-choice question has three distractors, four options with one key, and a stem. Every right response carried one mark, and every wrong response carried zero marks. To validate the achievement test, four PGT teachers, one from Basil School Vadodara, one from Vidyut Board Vidyalaya, two from Central Hindu School (CHS), and professors from various institutions of the country were consulted. These experts provided insightful advice on a variety of topics, including the test items' accuracy at each level of Bloom's taxonomy, their appropriateness and clarity, potential faults in the optional answers, and linguistic ambiguity. Before finalizing these 125 items for the initial draft of the Achievement Test, the researcher made the necessary corrections and improvements based on the expert feedback, including rephrasing some of the items and changing the distractors.

3.2.9.3 Final Draft: After incorporating all changes in the achievement test, many

items were discarded, and in the final draft, only 100 questions were included.

Table 3.10: Number of Items Based on Cognitive Domain

Sr. No.	Level of Bloom's Taxonomy	Item Number	Number of Items
1	Knowledge Level	1,2,3,4,13,14,15,16,25, 26,27,28,38,39,40,41,50, 51,52,53,62,63,64,65,74, 75,76,77,78	29
2	Understanding Level	5,6,7,8,9,17,18,19,20,21, 29,30,31,32,33,42,43,44, 45,46,54,55,56,57,58,66, 67,68,69,70,79,80,81,82, 83	35
3	Application Level	10,11,12,22,23,24,34,35, 36,37,47,48,49,59,60,61, 71,72,73,84,85,86	22

3.2.9.4 Scoring: In this test, every correct response to the question is assigned one mark, and an incorrect response to the question is assigned with zero mark.

3.2.10 PROCEDURE OF DATA COLLECTION

The aforementioned four instruments were used to gather data between June 2023 and November 2023 of the academic year 2023-2024. The researcher conducted experiments and collected data in person for one semester during this academic session of 2023-24. At that time, the control group was taught by the conventional method of science teaching.

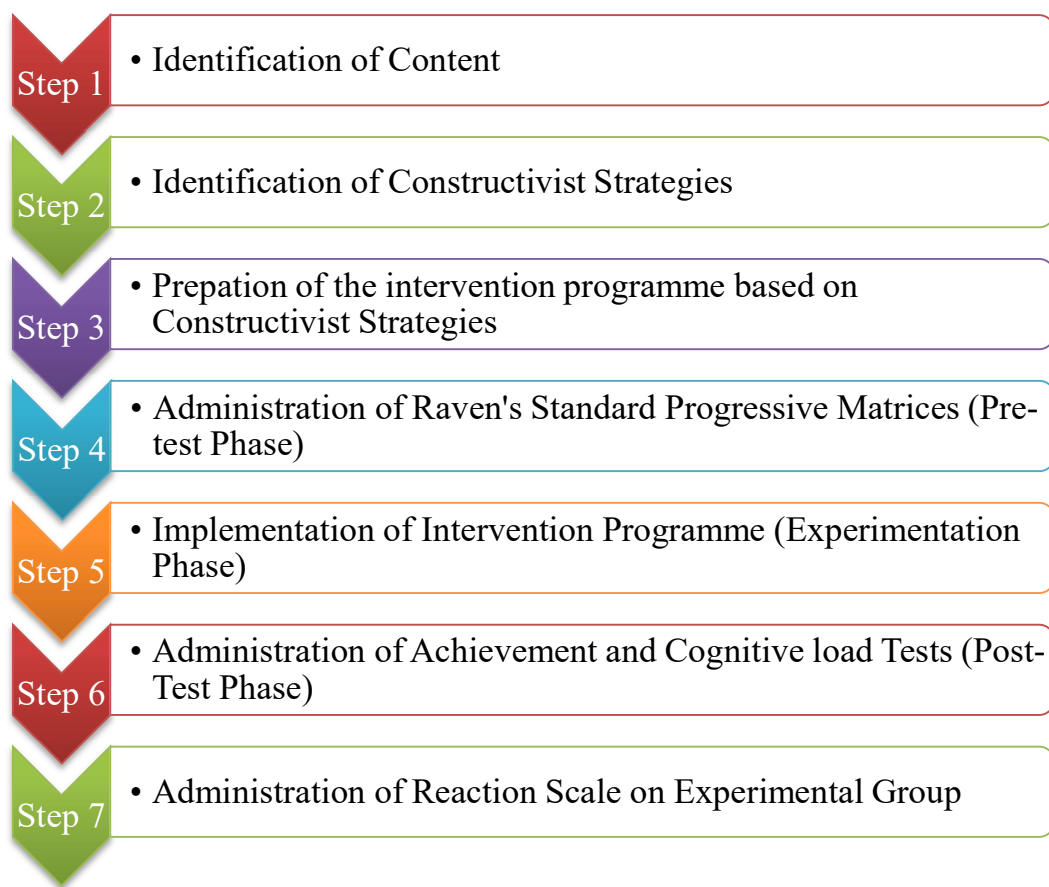


Figure 3.1 Steps of the Study

Phase 1. Identification of Content- The researcher thoroughly analyzed the textbook for the selection of content that can be taught through the constructivist approach.

Phase 2. Identification of Constructivist Strategies

For the selection of the constructivist strategies, the researcher reviewed studies as well as took the opinion of the expert from the science pedagogy and science subject who were working in the schools and university departments.

Phase 3. Preparation of Intervention Programme based on Constructivist Strategies-

The researcher took the whole syllabus of the first semester of class 9th for the intervention purpose. In the science book of class 9th, a total of 6 chapters were prescribed by NCERT.

Phase 4. Administration of Raven's Standard Progressive Matrices-

Phase IV was carried out at the starting of the academic year in June 2023. One standardized instrument was the Raven's Standard Progressive Matrices (SPM) test. First of all, the

researcher took permission from the principals of the two schools chosen to administer the intelligence test. In this phase, the experimental and control groups took the Raven's Standard Progressive Matrices (SPM) test during the first week of the academic year 2023-2024. The time duration specified in the standardized tool was one hour. The students received the booklet and the OMR sheet to record their responses. Within the allotted time, every student in the experimental and control groups finished the Raven's Standard Progressive Matrices (SPM) test.

Phase 5. Implementation of Intervention Programme: The pedagogical intervention program was implemented in the experimental group. The experiment continued for a whole semester. The researcher took utmost care that the teaching-learning process of students did not get hampered during the implementation of the intervention programme. At the same time, the control group was taught in the regular teaching process.

Phase 6. Administration of Achievement Test and Cognitive Load Scale: All the data was personally collected by the researcher throughout the study. Before implementing the pedagogical intervention, a pre-test was administered to the students of both experimental and control groups to measure their achievement and cognitive load. After implementing the strategies, a post-test on both groups was administered at the end of the session. For cognitive load, the researcher assessed it after the completion of the intervention programme.

Phase 7. Administration of Reaction Scale:

The researcher implemented the developed intervention programme for the duration of one semester, on the students for teaching science. After that, the researcher administered a reaction scale on the students to know their reaction to the developed pedagogical intervention programme.

3.3 DATA ANALYSIS

The collected data was analyzed using quantitative statistics techniques- Mean, Mean rank, Mann-Whitney-U test, Spearman's rho (ρ) and Intensity Analysis. The Mann-Whitney U test is the most suitable test for analysing the collected data because in the present study, the sampling technique was purposive sampling, and the data were not following the assumptions of normality.