CHAPTER 3

METHODOLOGY

CHAPTER III

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3.0 Introduction

This Chapter gives a detailed account of the nature, plan and procedure of the Study. It can be considered the backbone or the blueprint of the Study as it includes the research design - an outline based on which the research is conducted. In the present Chapter, the aspects of the methodology like population, sample, procedure for the development of the Instructional Package, construction of tools, research design, data collection techniques and procedure of data analysis have been discussed. The objective of the present Study is to assess the effectiveness of the Instructional Package on the development of content-specific higher-order-thinking skills of students of IX Standard in Mathematics. The details of the methodology adopted for the Study are presented in the following subheadings.

DIFFERENT PHASES OF THE STUDY

The Study was conducted in the following phases:

Phase 1: Development of the Instructional Package and the Research Tools

Phase 2: Methodology adopted for implementation of the Instructional Package

Phase 3: Procedure used for analysing the data

PHASE I: DEVELOPMENT OF THE INSTRUCTIONAL PACKAGE AND RESEARCH TOOLS

3.1 Development of Instructional Package

The Instructional Package was developed based on the need to enhance the ability of the students to answer questions that require higher order thinking skills, by focusing on teaching strategies that aid in conceptual understanding and mathematical thinking with respect to the content of ‘Real Numbers’. The mathematical ability and other learning behavior of the students of class IX were also considered. Actual development of the Instructional Package is explained in the next paragraph. The developed draft was shown to experts in the field of Mathematics, Education and English. The experts were informed about the observations regarding level of the students and their mathematical abilities. The investigator incorporated the suggestions given by the experts and finalized the developed Instructional Package (Chapter IV).

For developing the Instructional Package, investigator had taken the unit Real Numbers from class IX Mathematics textbook of Gujarat Secondary & Higher Secondary Education

Board (GSHSEB) English version published in the year 2011 followed also in the implementation year 2017.

3.1.1 Teaching strategies to be used for designing the instructional package

The first step in the designing of the Instructional Package was to decide on the teaching strategies that can be used in Mathematics so as to offer ample opportunities to students to involve in higher order thinking throughout the process of teaching and learning on a continuous basis. An investigation of various researches, learning theories and the NCF 2005 document led the investigator to select the following teaching strategies and techniques to be used to design and transact the concepts of Real Numbers to Class IX students of Mathematics:

a. Cognitivist Teaching Strategies

For the present Study, the cognitivist teaching strategies that were integrated with the content were –

- naming critical, additional, false features of the concept
- comparing the new to the already known concept
- giving best examples and non-examples
- identifying other similar or connected concepts
- classifying or chunking information
- using real world examples
- conducting discussions
- providing visuals

(Thomas & Thome, 2009; Kelly, 2012; Rittle-Johnson, 2014; Schnieder, 2014).

b. Use of Mathematical Connections

Mathematical connection for the present Study specifically means,

- To show students the connection that exists (1) between the new concept with the previously learnt concepts (2) within and between different content areas in Mathematics; (3) between Mathematics and the real-life scenarios of the child (Perry & Docket, 2008 cited in Ndiung & Nendi, 2018).
- To show students mathematical connections among content areas, among mathematical processes and within their own thinking.
- To use Concept maps to show the relationship that exists between the new concept in-hand to the variable known and unknown contexts.

- To use hand-outs or review sheets to help students see connections among concepts (Bartels, 1995b).

c. Use of Questioning and Probing skill

For the present Study, questioning and probing refers to –

- Posing questions and tasks that elicit, engage, and challenge each student's thinking (NCTM, 1991; Crowl et al., 1997).
- Phrasing questions that align to Bloom's taxonomy higher-challenge areas that address analysis, synthesis and evaluation and can spur higher order thinking.
- Framing Focus-questions that lead student through the steps of thinking.
- Asking open-ended encouraging students to think beyond textbook-based structured answers [TESS-India, Barwell, 2011; Hoffman & Brahier, 2008; Suurtamm et al., 2015)].
- Asking students to clarify and justify their ideas orally and in writing (NCTM, 1991; Bautista, n.d.).

d. Use of Generalization techniques

For the present Study, the method called Empirical Generalization (Krutetskii, 1976) has been used. It is a gradual process of analyzing a series of concrete examples in which the non-essential attributes are systematically changed. Teaching strategies for the same

- would need to engage students into inductive reasoning i.e. to observe or work with given set of data, analyse it in the process and identify the pattern or the relationship that exists within the components and synthesize them to infer a mathematical rule, property, law, formula or definition (Sriraman, 2004).
- Ley (2016) proposed a blend of 'discovery learning' and 'direct instruction' to be used appropriately to promote generalization (Alfieri et al., 2011).

e. Use of Estimation techniques

According to Smart (1982) "*to estimate* means to form an approximate opinion of size, amount, or number that is sufficiently exact for a specified purpose". For the present Study, teaching strategies integrating estimation techniques are:

- Posing a problem with known backgrounds and encouraging students to guess the answer (numeric value/ shape/ distance/ position/ etc.).
- Probing further to modify the guess to a reasoned guess. This can be done by having students estimate an unknown quantity by either comparing it to a known quantity or partitioning it into known quantities or by using mental computation (Leutzinger et al., 1986).

- Strengthening estimation skills by having students verbalize their thinking.
- Apart from hypothesising and validating the reasoned estimate, making quick informal estimates, 'rule of thumbs' can be generously used during content delivery. 'Rule of thumb' operations mean applying mental hooks to a situation (Mitchell et al., 1999).

f. Use of Visualization techniques

Visualization in Mathematics can be described in three distinct ways which is used in the present Study:

- Visualization Object, which involves interpretation of physical objects like illustrations, animations, computer-generated displays etc. to understand a mathematical idea.
- Introspective Visualization is an imaginative construction of some visual experience without a visualization object. Mental objects picturized in the mind.
- Interpretative Visualization involves interpretation of meaning from visualization objects or introspective visualizations, which are cognitive functions (Philips et al., 2010).

The next step in the development of Instructional Package was selection of the content, content- analysis of the same, which was followed by re-sequencing of the topics within the content to establish logical connections between each.

3.1.2 Selection of content

The investigator went through the Mathematics textbooks of classes VII to X which is prescribed by GSHSEB. Analysis of the same revealed a sudden leap from the concrete level Mathematics in class VIII syllabus to more abstract and higher-level Mathematics in class IX. This called for application of pedagogic practices in the classroom that offer more opportunities to generalize, prove, justify, visualize, estimate. The content 'Real numbers' included in the class IX syllabus of GSHSEB was chosen for the development of the Instructional Package. The chosen content was an important connecting link between the Numbering systems studied by students till class VIII and further was very relevant for higher classes. Moreover, the textual content of the unit Real numbers in class IX (similar in GSHSEB and CBSE) had some vivid flaws like: sequencing of topics were not appropriate, contexts of some topics remained unexplained, abstract elements were not concretized, there were gaps in transition from one piece of knowledge to another, and above all, hardly any effective teaching strategies were demonstrated for teachers to display effective pedagogic practices in classroom. It was very heavy on theory and did not allow easy transition for students from class VIII activity-based content to a content that required mental skills of observing patterns, generalizing, visualizing, estimating, connecting, reasoning and proving.

The investigator also observed regular teachers in different schools of Vadodara, teaching 'Real numbers' in class IX, and found that only traditional-conventional method was adopted by them. Also, the students' mathematical abilities and their learning behaviors were noted which substantiated their lack of conceptual knowledge. Thus, the content 'Real Numbers' of class IX of the GSHSEB syllabus was considered by the investigator as a base to develop the Instructional Package.

3.1.3 Original order of the topics in the GSHSEB text books

The first step in the development of Instructional Package was content-analysis, which was followed by re-sequencing of the topics within the content to establish logical connections between each. The order in which the sub-topics of the unit Real Numbers was structured in the GSHSEB textbook is given below.

1. Introduction

- Brief description of Natural numbers, Whole numbers, Integers and Rational numbers
- Definition of Rational numbers
- Relationship of Rational numbers with N, W, and Z
- Finding Rational numbers between two given Rational numbers.
- Remark that 'There are infinitely many Rational numbers between any two given Rational numbers' without any explanation or elaboration.

2. Irrational numbers

- Definition: 'A number is called Irrational if it cannot be written in the p/q form, where p and q are Integers and $q \neq 0$'.
- Directly some examples of Irrational numbers given without any further explanation as to why are they Irrational.
- Concept of Real numbers: All Rational and Irrational numbers form the set of Real nos.
- Real Number line
- Locating some Irrational numbers of Number line by the use of Pythagoras theorem, with no other explanation on constructions.
- With only two examples of 'locating $\sqrt{2}$ and $\sqrt{3}$' students expected to understand '$\sqrt{n}$ for any positive Integer n can be located after $\sqrt{n-1}$ have been located'.
- Classroom activity to construct a 'square root spiral' with reference of the Number line, thus missing out the purpose.

3. Real Numbers and their Decimal Expansions

- Using three different examples to guide students to understand *terminating* and *non-terminating-recurring* decimal expansions. Here students are given scope to see the pattern and understand the given conclusions.
- Method shown to prove that *terminating* and *non-terminating-recurring* decimals are Rational numbers. Thus, concluding that all *non-terminating-non-recurring* decimals are Irrational numbers.
- Decimal expansions of $\sqrt{2}$ and π are shown.
- Finding Irrational numbers between two Rational numbers with one example. No explanation further about the right way to write Irrational decimal expansions.

4. Representing Real Numbers on the Number Line

- Representing decimal numbers up to three decimal places on the Number line by the process of successive magnification.
- Students given a scope to visualize the representation of recurring decimal number.

5. Operations on Real Numbers

- Brief description of the commutative, associative, distributive and closure properties for Rational numbers and a direct statement that Irrational numbers also satisfy these properties.
- Some examples showing addition, subtraction multiplication and division of Irrational numbers to prove the properties of different operations on Irrational numbers.
- Representation $\sqrt{x}$ for any positive Real number x on the Number line geometrically.
- Square root rules and using them to simplify expressions with Irrational numbers.
- Rationalizing the Irrational denominators in fractions.

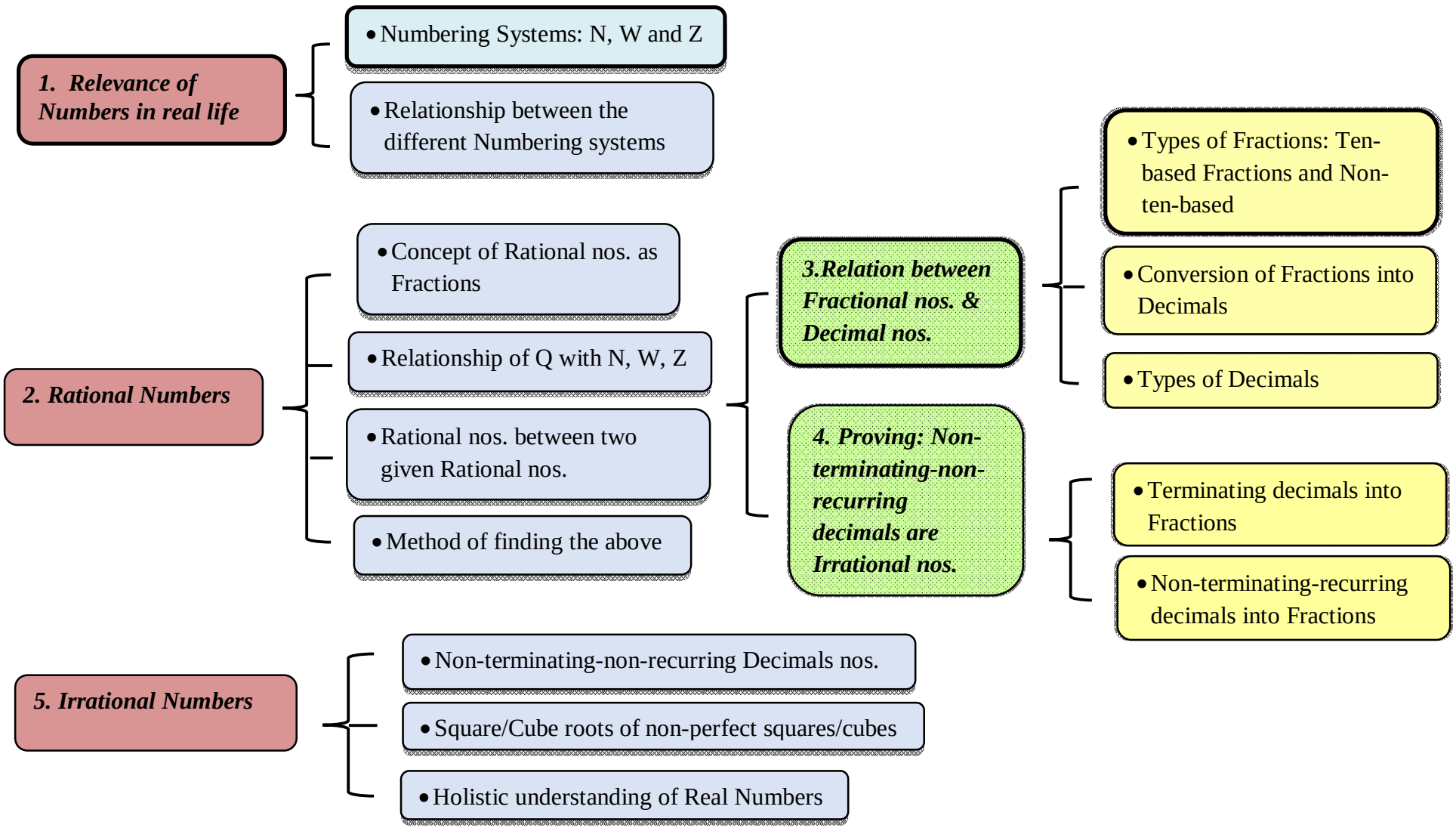
6. Laws of Exponents for Real Numbers

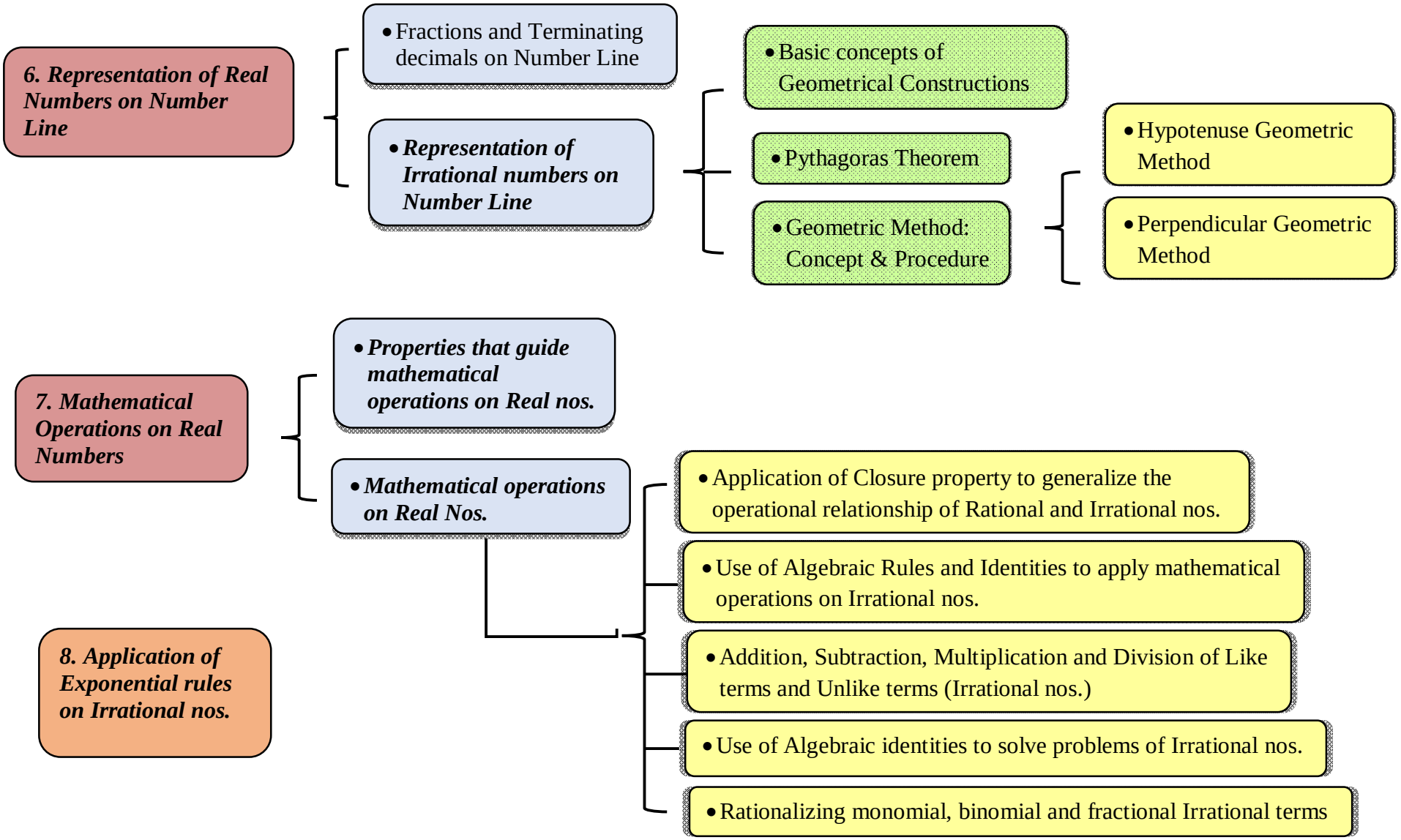
- Application of the laws on Irrational numbers.

3.1.4 Re-sequenced structure of the topics for instructional package

In order to re-sequence the topic, the gaps in the inter-connections within the sub-topics sequenced in the textbook were first identified. Also the sub-topics which needed more elaboration, or background support were identified. For example, the topic 'Irrational Numbers' which was a completely new topic for students, needed a stronger background; 'Representation of Irrational numbers on the Number line' also needed support of concepts like 'Pythagoras Theorem' and 'Constructions'. Similarly, 'Operations on Real numbers' cannot be introduced without revisiting 'Properties applicable to the Numbering system- Real Numbers'. Thus, the following logically sequenced set of concepts emerged as a result of an in-depth content analysis.

Re-sequenced structure of the topics for Instructional Package




6. Representation of Real Numbers on Number Line
Fractions and Terminating decimals on Number Line
Representation of Irrational numbers on Number Line
Basic concepts of Geometrical Constructions
Pythagoras Theorem
Geometric Method: Concept & Procedure
Hypotenuse Geometric Method
Perpendicular Geometric Method
7. Mathematical Operations on Real Numbers
Properties that guide mathematical operations on Real nos.
Mathematical operations on Real Nos.
8. Application of Exponential rules on Irrational nos.
Application of Closure property to generalize the operational relationship of Rational and Irrational nos.
Use of Algebraic Rules and Identities to apply mathematical operations on Irrational nos.
Addition, Subtraction, Multiplication and Division of Like terms and Unlike terms (Irrational nos.)
Use of Algebraic identities to solve problems of Irrational nos.
Rationalizing monomial, binomial and fractional Irrational terms

3.1.5 Design of lesson plans and worksheets

The underlying purpose behind each Lesson Plan was to provide conceptual clarity with specific and holistic understanding of each concept and scope for mathematical thinking to students. The Lesson plans included both cognitivist and constructivist modes of content delivery with guided self-discovery approaches. For the re-structured topics of the Chapter 'Real numbers', General and Specific objectives were designed. According to each Specific objective, Teacher-Student activities were designed based on the Teaching strategies described in the earlier section. Befitting the content of respective Lesson Plan - Worksheets, Self-learning materials, Assessment sheets, and Power point presentations were also made. Most of the Worksheets were designed to help students to work on their own, identify connections and make conjectures. They included questions for regular practice work as well as for higher order thinking. The Self-learning materials targeted to provide opportunity to students to self-learn at their own pace. The Power-point-presentations were to be used as teaching aids by teachers. Most of the slides were made using custom-animation so that teacher can adjust explanations with the visual displays in a sequential step-wise manner and save considerable teaching time. The Assessment sheets included HOTS questions to train minds for the same. The Lesson plans, Worksheets, and Assessment sheets (Evaluation 1 and 2) of the Instructional Package has been included in Chapter 4 of this report. Self-Learning Materials and Power Point Presentation are included in Appendix B (4) and B (2) respectively.

3.1.6 Modifications made in instructional package based on expert feedback

The developed draft was shown to experts in the field of Mathematics, Education and English. Some of the suggestions that were put forward by the Experts are as follows. Also are mentioned different strategies used to address them.

- The Package was considered to be too lengthy to be implemented within the school curricular and time limits. This feedback was addressed by developing, Self-learning materials and PPTs, so that class time consumption could be reduced.
- The Worksheets were good to develop analysis-synthesis skills among students, but experts believed that they might not cause content-related learning and thus should be followed by or supported with consolidations, explanations or practice work. This feedback was responded by including Teacher Explanations and Teacher Consolidations after every Worksheet. Wherever needed, Practice sheets or practice work to be completed at home were given to the students.

- Certain contents included in the Package were considered to be beyond the cognitive levels of most of the Class IX kids, thus were suggested to be eliminated or simplified. The contents suggested were:

- The mathematical reasoning behind the fact in the definition of Rational numbers 'for a Rational number p/q, the mathematical reasoning of $q \neq 0$). Thus, instead of using the non-terminating decimal method as the reasoning, the same was explained by using the concept – Division as repeated subtraction.
- The use of properties of Closure, Commutative, Associative, Distributive for Real numbers to teach Operations on Real numbers, might make it more complex. To address this feedback, the language in the Lesson Plan was simplified and the connection between the Properties and the Operations on Real numbers was made more vivid and clear.

Thus, the contents that were considered to be not appropriate for the student levels were either removed or modified or supported by other strategies.

- Concepts of Prime numbers and Composite numbers included while briefing students regarding Whole numbers; were asked to be eliminated. This feedback was followed and the said portion was eliminated.
- The concept of 'Denseness of Real numbers' was proposed to be added in the Package. A separate Lesson Plan was made to include this concept.
- The HOTS teaching strategies were asked to be clearly mentioned for every Lesson. This was included at the end of every Lesson Plan.

The Language expert and Education expert mostly had positive feedback and hardly suggested any changes in the Instructional Package.

3.2 Development of Achievement Tests

Achievement tests were developed by the investigator for different purposes.

1. Pretest (to prove equivalence of Experimental and Control group)
2. Evaluation 1 (Formative Assessment within Instructional Package)
3. Evaluation 2 (Formative Assessment within Instructional Package)
4. Posttest (Tool for Data collection)

Although the purpose for the Achievement tests were different as mentioned above, they have been designed on the same lines. The Achievement tests included HOTS questions that aligned to the levels/competencies of Bloom's Taxonomy: Comprehension, Application, Analysis, Synthesis and Evaluation. Application of the Higher level competencies while

responding to the HOTS questions would also require some Basic level competencies. The specifications for each of the levels considered while designing the questions for the above tests are given in the Table1 below:

Table 1: Components of Higher Order Thinking Skills included in Questions of the Achievement Tests

	Basic level Cognitive skills/Competencies
	• calculation skills • direct use of presently or previously learnt mathematical concepts, rules, theories, or properties; and • use of algorithmic procedures
Cognitive levels	**Higher level Cognitive skills/Competencies**
Comprehension	• Understanding information • Grasp meaning • Interpret facts, compare, contrast • Order, group
Application	• Use information • Use methods, concepts, theories in new situations • Solve problems using required skills or knowledge
Analysis	• Identification of components • Organisation of parts • Recognition of hidden meaning
Synthesis	• Use old ideas to create new ones • Generalise from given facts • Relate knowledge from several areas • Predict, draw conclusions
Evaluation	• Compare and discriminate between ideas • Make choices based on reasoned argument • Verify value of evidence

[Adapted from: Bloom, B.S.(Ed.) (1956) Taxonomy of educational objectives: The classification of educational goals: handbook I, cognitive domain]

Blueprints for the above Achievement tests were then developed by the investigator, which are shown in the Appendix A (3), (6), Appendix B (3). A Question-Bank including several open-ended questions for each of the above levels were then prepared. The First-Draft of the Posttest (used in the experiment) question paper was then prepared by the investigator

[Appendix A (1)]. The draft was then sent to Mathematics experts, along with the Answer key and the scoring Rubric. Based on the suggestions of the experts the Question paper was modified and the final version is shown in Appendix A (2). On the same lines the Question papers for Pretest [Appendix A (5)], Evaluation-1 and Evaluation-2 (in Chapter IV) were prepared by the investigator.

3.2.1 Purpose of the achievement tests

In this Study the tests were constructed to (i) judge the student's ability to respond to HOTS questions, which required them to understand the content well; apply required computations; apply the known concepts in different contexts; analyze the components and provide solutions; synthesize different concepts to generalize or conjecture rules or properties; and evaluate the different choices to justify or verify mathematical facts specific to the content 'Real Numbers'. (ii) to provide mental alertness to students to respond to HOTS questions for different smaller chunks of the content using Evaluation 1 and Evaluation 2 as a part of the Instructional Package. (iii) to evaluate the Methods of teaching used in the Instructional Package over the Conventional teaching method. (iv) to use the Pretest to assess the entry behavior of both the groups; and the Posttest to assess the criterion behavior of students.

3.2.2 Specification of concepts included in achievement tests

The content that was included in the four Achievement tests were from the unit 'Real Numbers'. The syllabus considered to prepare the question paper for Pretest included 'Rational Numbers' as prescribed in the VIII standard Mathematics GSHSEB syllabus. The syllabi included in Evaluation1, Evaluation 2, and Posttest question papers were taken from the unit 'Real Numbers' of IX standard Mathematics GSHSEB syllabus. Weightage to different topics was allotted on the basis of the length of the topic, its complexity and its importance for future use. Weightage given to different aspects in the Achievement tests were as shown below in Tables 2, 3, 4 and 5.

Table 2: Weightage given to sub-units in Pretest

Sr. No.	Sub – Units	Marks
1	Rational Numbers & Numbers within	**11**
2	Relation between the different Numbering systems included in Rational Number	**10**
3	Representation of Rational Numbers on Number Line	**8**
4	Properties of Rational Numbers	**8**
5	Mathematical Operations on Rational Numbers	**14**
6	Algebraic Operations on Rational Numbers	**9**
Total		**60**

Table 3: **Weightage given to sub-units in Evaluation 1**

Sr. No.	Sub – Units	Marks
1	Rational numbers as fractions	**10**
2	Relationship between the numbers that lie in N, W, Z and Q	**14**
3	Finding Rational numbers between two given Rational nos.	**8**
4	Identification of the position of a given Rational numbers	**5**
5	Concept of Rational numbers as an infinite set	**4**
6	Relation of Rational numbers with Decimal numbers	**10**
7	Types of Decimal expansions	**9**
Total		**60**

Table 4: Weightage given to sub-units in Evaluation 2

Sr. No.	Sub – Units	Marks
1	Representation of decimal numbers on Number line	**8**
2	Difference between Rational numbers and Irrational numbers	**12**
3	Finding Irrational numbers between given numbers	**8**
4	Use of Pythagoras theorem on Irrational numbers	**12**
5	Representation of Irrational numbers on Number line	**8**
6	Properties of Rational numbers	**12**
Total		**60**

Table 5: **Weightage given to sub-units in Posttest**

Sr. No.	Sub – Units	Marks
1	Real Numbers & Numbers within	**10**
2	Relation between the different Numbering systems included in Real Number	**8**
3	Representation of Real Numbers on Number Line	**10**
4	Properties of Real Numbers	**8**
5	Mathematical Operations on Real Numbers	**14**
6	Algebraic Operations on Real Numbers	**10**
Total		**60**

3.2.3 Weightage to different cognitive level questions in the achievement tests

The cognitive domain of the Bloom's taxonomy used for creating HOTS questions (as shown in Table1), were taken as the basis to design the Achievement tests. The weightage given to each of the Cognitive levels: Comprehension, Application, Analysis, Synthesis and Evaluation were kept equal in all the four tests. The weightage to different levels in all the four tests are shown in Table 6.

Table 6: Weightage to different Cognitive Levels

Sr. No.	Cognitive Levels	Marks
1	Comprehension	12
2	Application	12
3	Analysis	12
4	Synthesis	12
5	Evaluation	12
Total		**60**

3.2.4 Preparation of blueprint for the achievement tests

To ensure that the Achievement tests satisfy the most important criterion – 'content validity'- blue prints of each of the tests were prepared and discussed with experts. The blue print is a comprehensive chart containing the content to be covered in the test, objectives, number of questions per objective and per sub-topic, and marks allotted to each question. Blue prints of the Pretest, Posttest are attached in Appendix A (3), (6) and Evaluation 1, Evaluation 2 are attached in Appendix B (3).

3.2.5 Selection of item format for the achievement tests

The investigator selected the format of subjective type items, because the purpose was to test the students' conceptual knowledge, their understanding of the concepts, their abilities to apply, analyse, synthesize and evaluate concepts in new contexts. Thus, the reasoning, logic and the justifications used by students to respond to questions needed to be in explicit form to understand their mental abilities. While preparing the subjective type items, the following rules were followed.

(1) Questions were framed to be as simple and concise as possible to ensure valid and reliable test results.

(2) Questions were framed so as to ensure students comprehend, apply, analyse, synthesize and evaluate and show higher-order-thinking-skills. Each of the components aligned to the specifications shown in Table 1.

(3) Each question was made independent i.e. ensured that one question did not provide clue to the other.

(4) Barring the first Comprehension level question, it was ensured that each question was based on a new premise with strong connection to the concepts taught in the class.

Thus, keeping all the above points in account, subjective type Achievement tests were prepared by the investigator, which were further scrutinized by experts. The modifications suggested were incorporated to ensure validity of the tests.

3.2.6 Test length and duration

The Achievement tests included fifteen subjective questions of four marks each, adding up to sixty marks. Based on the variable lengths and difficulty level of each item, two hours were allotted for each Achievement test.

3.2.7 Construction of test items in the achievement tests

The final draft for all the four Achievement tests were prepared which included 15 questions each. The main purpose of the tests - to measure higher order thinking skills of students – was kept in mind while deciding on the questions to be included in the tests. The drafts were given to experts for getting their suggestions for improvement (List of experts in Appendix D). The modifications were made accordingly. Questions were arranged according to lower to higher levels of difficulty; the easiest questions were included in the beginning for motivating the students. The final Achievement tests were then printed with student response area provided within, serving the purpose of an Answer Sheet as well.

3.2.8 Evaluation of the achievement tests

1. Reliability of the tests

"Reliability is the degree of consistency that the instrument or procedure demonstrates: whatever it is measuring, it does so consistently" (Best & Kahn, 2012). In the present Study, four Achievement tests were constructed with an aim to train and measure the higher order thinking skills of the students, which would be reflected by the scores provided (as per the Scoring Rubric described in the next section). To check the reliability of the tests, after they were designed and modified according to the experts' suggestions, they were administered on 36 students. The responses were then scored according to the Scoring Rubric. The coefficient of correlation (r) was then calculated between each set of scores. The reliability coefficient was then calculated using Spearman Brown Prophecy formula $R = 2r (r + 1)$ where R is the reliability coefficient and r is the coefficient of correlation between the different tests.

The reliability coefficient of Pretest and Posttest was calculated as 0.88; Pretest and Evaluation 1 was 0.86; Pretest and Evaluation 2 was 0.84; Evaluation 1 and Evaluation 2 was 0.87; Evaluation 1 and Posttest was 0.85 and Evaluation 2 and Posttest was 0.82. This proved the reliability and the equivalence between the different tests administered during the present Study for varied purposes.

2. Validity of the Achievement tests

"Validity is that quality of a data-gathering instrument or procedure that enables it to measure what it is supposed to measure" (Best & Kahn, 2012). Validity is always concerned with a specific use of assessment results and the soundness of our proposed interpretations of those results. In case of Achievement tests, content validity and empirical or statistical validity are important.

- ***Content Validity***

"Evidence for the validity of the test content refers to the degree to which the test items actually measure, or are specifically related to, the traits for which the test was designed and is to be used" (Best & Kahn, 2012). For the present Study, content chosen was from the Mathematics syllabus of IX standard, 'Real Numbers'. The four Achievement tests were so designed that the Pretest and the Posttest included the whole content and the mid tests Evaluation1 and Evaluation 2, included smaller chunks of units. The Pretest included similar contents in nature and procedure as in Posttest but was limited only to 'Rational Numbers' unlike Posttest which tested the concept -'Real Numbers'. Since the time interval between the Pretest and the Posttest was not very large, this variation in content resolved the threat to Internal Validity. Content evidence is based on careful examination of course textbooks,

syllabi, objectives, and the judgments of subject matter specialists. In the present Study, the Achievement tests were constructed keeping in view all the above points on one hand and experts' comments on the other, the procedure adopted for constructing the tests provides evidence regarding the content validity of the tests.

- ***Construct Validity***

Construct Validity is the degree to which test items and the structure of a test can be accounted for by the explanatory constructs of a sound theory. A construct is a trait that cannot be observed (Best & Kahn, 2012). In the present Study, the tests had been constructed with an objective to assess the higher order thinking abilities of students, which can be considered as the construct for the tests. In order to satisfy this condition, the tests were constructed in lines with the cognitive domain of Bloom's taxonomy that aligns to higher-order-thinking-skills. Specifications used in the Bloom's theory were considered as guidelines while framing the questions and designing the Achievement tests. Comprehension level questions, though not considered to arouse higher order thinking according to Bloom's taxonomy, were included as test items, as 'comprehension' is the basic skill required to go ahead and exercise the other higher order thinking skills. Specific to the present Study, the Comprehension level questions had solutions which had procedural similarity as taught in the class, but were made structurally different and unknown from the usual practice in classroom. As students would have to analyze the outer structure to decipher the usual procedure to be used to solve the problem, the Comprehension level questions were considered as an appropriate inclusion in the present Study testing tools.

Experts of the field scrutinized each question to check appropriateness of the construct, thus providing evidence regarding the construct validity of the tests.

3. Practicability of the Achievement tests

Practicability of a test is a function of the ease of administration, readiness of interpretation, economy in initial cost, possibility in reusing materials, time required for scoring and analyzing the results. The Achievement tests constructed for the present Study, are easy to administer as it is in printed form. It is economical, as it is reusable, as the answer sheets can be provided separately. The Answer key and the Scoring Rubric make the task of correcting and scoring the papers not that cumbersome. Though, the subjective nature of the tests makes the practicability of the tests limited.

3.3 Development of Tools

'Posttest' was the tool that was mainly used to analyze the relative achievement and the higher order thinking skills for the content 'Real Numbers' of the students exposed to

Instructional Package in comparison to the students exposed to Conventional method of teaching. The 'Reaction scale' [in Appendix A (7)] designed by the investigator served the purpose of understanding the classroom instructions, and teaching strategies used through Instructional Package on the basis of the opinions given by the students.

The steps used to design the Posttest are described in detail in the above section 3.2 along with the procedure used to develop the other Achievement tests. A specific Scoring Rubric for the Posttest [in Appendix A (4)] was developed by the investigator, which is described in the next section.

3.3.1 Scoring rubric to score achievement scores and cognitive competencies

An Investigator-Made Scoring Rubric was made to investigate Basic level and Higher level competencies and the Achievement scores of the sample students. While developing the Achievement tests the investigator took care that the student responses evolve tentatively due to Basic level and Higher level cognitive skills. Basic level cognitive skills/competencies included calculation skills; direct use of presently or previously learnt mathematical concepts, rules, theories, or properties; and use of algorithmic procedures (Table 13 in Chapter V). Higher level cognitive skills/competencies comprised of higher order thinking skills as tabulated for each question included in the Posttest (shown in Table 14 in Chapter V). An Investigator-Made Scoring Rubric and the Answer key for the Posttest [attached in Appendix A (4)] was developed that described the Sample Responses for all the 15 questions, and also elaborated the basis on which each answer was scored for the Basic and the Higher level competencies.

3.3.2 Development of the reaction scale

A Reaction Scale was designed to attain the feedback of students regarding the Instructional Package, worksheets, achievement tests, teaching approaches adopted during implementation of Instructional Package, learning approaches used by them, attitude towards Mathematics and the content 'Real Numbers' in specific. A five-point Likert scale with responses Strongly Agree, Agree, Not Decided, Disagree, Strongly Disagree was prepared. A set of 25 statements were organized in the sequence checking the implementation of Instructional Package Lesson plans, students' understanding of the content and the teaching strategies used, attitude towards the content and subject, effectiveness of the worksheets, and the items used in the Achievement tests. The Reaction scale was evaluated by experts and modifications as per the suggestions made were done. The Reaction Scale is attached in the Appendix A (7).

PHASE 2: IMPLEMENTATION OF INSTRUCTIONAL PACKAGE

3.4 Initial Try-Out of Instructional Package

Investigator approached several English medium schools following the GSHSEB syllabus in the city of Vadodara for seeking permission to implement the package. Among those, two schools permitted the investigator for the same. One school was randomly selected for initial try-out of the Instructional Package and the other for the final implementation. The investigator observed the classroom teaching and the classroom environment of both the sections of Class IX of the school for the initial try-out and found no difference and thus randomly selected one of the sections for the initial try-out of the Package. The investigator took 25 sessions of 35 min each to implement the package in this phase.

3.4.1 Modifications incorporated in the instructional package after the initial try-out

The Instructional Package was modified on the basis of - the gaps found in the previous knowledge of students of class IX, student responses, student work, students' aptitude limitations, hurdles while implementing the worksheets and assessments.

- Major gaps identified in the previous knowledge of the students were:

  - Understanding of the students regarding the Numbers in the form of Integers, Fractions, and Decimals were purely procedural and structural; conceptual understanding on the same was absolutely missing.

  - Students did not have an understanding of the relationship of the 'Properties-Closure, Commutative etc.' with 'Numbering system' i.e. 'The Properties are the guidelines for using the different Operations on the numbers belonging to a respective Numbering system'- this knowledge was missing.

  - Students lacked efficiency in solving multiple operational problems of Rational numbers.

  - 'Laws of Exponents' needed a revision as well.

  - Basics on Geometrical constructions also needed to be strengthened for the topic – Representing Irrational numbers on Number line.

Thus, the lesson Plans were modified by making space for previous knowledge in Self-learning materials and also in classroom teaching; the conceptual understanding as well as the procedural components of the identified sub-topics were re-shaped.

- There were certain sub-topics that needed more rigour in terms of – practice to be given to students on the procedural aspects. The sub-topics were:

  - Proving a recurring Decimal number to be a Rational number

- Operations on Irrational numbers with square root
- Operations on irrational numbers with exponents
- Representation of Irrational numbers on Number line

Thus, more practice work was designed and delegated on the above topics during the Final implementation of the Instructional Package.

- While solving the initial Worksheets, students needed a lot of hand-holding and explanations. Also, solutions drawn by students and checking their responses by the teacher, was inconvenient when work was done by the students in Notebooks.

Relevant instructions and explanations were included for the Worksheets in the Lesson Plans. Worksheets were converted to printed working sheets with required space for solutions.

- The 'Thinking tasks' was not appropriately happening in the classroom scenario with active 35 to 40 students. Thus, part of the Worksheets with 'thinking tasks' were done in class and part of the same was given as home tasks so that students can work in individualized undisturbed environments.
- The Formative assessments had to be given more time and needed simplification to some extent. Thus, Formative assessments were also modified in terms of simplified language and content.

3.5 Final Implementation of Instructional Package

Investigator implemented the Instructional Package in Class IX in one of the English medium schools of Vadodara. The school had two sections of Class IX. The classes were intact and could not be disturbed. Two equivalent groups were formed according to comparable mean and standard deviation of the Mathematics Achievement scores of Class VIII of the samples taken from the school records. The Pretest was conducted on both groups during the same time interval (2 hours), to check the equivalence of both the groups with respect to their responses to HOTS questions.

3.5.1 Formation of equivalent groups

1. Equating through previous class (VIII) scores in Mathematics

The Achievement scores of the previous year (class VIII) of the sample students were taken from the authorities of the School in which the experiment was to be conducted. The samples were now distributed in two sections, Section A and Section B. Table 7 shows the original Achievement scores (class VIII) of both the Sections and Table 8 shows the statistically equated one.

Table 7: Original Achievement Scores

Section A			Section B	
Sr. No.	**Marks (100)**		**Sr. No.**	**Marks (100)**
1	61		**1**	65
2	93.5		**2**	80
3	76.5		**3**	45
4	83.5		**4**	77.5
5	68		**5**	59
6	95.5		**6**	52
7	74.5		**7**	93
8	68		**8**	90.5
9	47		**9**	83.5
10	87.5		**10**	50
11	58		**11**	35.5
12	77.5		**12**	67
13	72		**13**	46
14	82		**14**	73.5
15	71.5		**15**	82.5
16	80		**16**	43.5
17	53		**17**	48
18	55.5		**18**	68
19	84.5		**19**	87
20	42.5		**20**	80
21	65		**21**	85.5
22	52.5		**22**	78.5
23	78		**23**	74.5
24	70		**24**	65
25	77.5		**25**	48
26	75.5		**26**	47
27	72		**27**	66
28	38		**28**	91

Table 8: Statistically Equated Scores

Section A			Section B	
Sr. No.	**Marks (100)**		**Sr. No.**	**Marks (100)**
1	61		**1**	65
2	93.5			
3	76.5		**3**	45
4	83.5		**4**	77.5
5	68			
6	95.5			
7	74.5		**7**	93
8	68		**8**	90.5
9	47		**9**	83.5
10	87.5		**10**	50
11	58		**11**	35.5
12	77.5		**12**	67
13	72		**13**	46
14	82		**14**	73.5
15	71.5		**15**	82.5
16	80		**16**	43.5
17	53		**17**	48
18	55.5		**18**	68
19	84.5		**19**	87
			20	80
21	65		**21**	85.5
			22	78.5
23	78		**23**	74.5
24	70		**24**	65
25	77.5		**25**	48
26	75.5		**26**	47
27	72		**27**	66
			28	91

29	56		**29**	80.5		**29**	56		**29**	80.5
30	79.5		**30**	64		**30**	79.5		**30**	64
31	50		**31**	83.5		**31**	50		**31**	83.5
32	40.5		**32**	67		**32**	40.5		**32**	67
33	88.5		**33**	76		**33**	88.5		**33**	76
34	30		**34**	64		**34**	30		**34**	64
35	52.5		**35**	76.5		**35**	52.5		**35**	76.5
36	75		**36**	56.5		**36**	75			
Mean	**67.55556**		**Mean**	**68.05556**		**Mean**	**68.83333**		**Mean**	**68.82813**
SD	**16.39894**		**SD**	**15.70386**		**SD**	**16.05881**		**SD**	**16.06068**
N	**36**		**N**	**36**		**N**	**33**		**N**	**32**

As shown in Table 8, the Mean of the Achievement scores of the students in Section A is 68.8333 and that of Section B is 68.82813 of class VIII. The SD of the Section A data is 16.05881 and that of Section B is 16.06068. This proves the homogeneity of both the groups. Thus, three samples from Section A and four samples from Section B had to be eliminated to form equivalent groups.

2. Equating the groups through the Pretest scores

Pretest that was designed using HOTS questions on the topic Rational Numbers was administered to students of both the Sections A and B of class IX. The Pretest scores of both the groups are tabulated below in Table 9.

Table 9: Pretest Scores of Section A and Section B

Pretest Scores (Sr. No. 1 – 20)				**Pretest Scores (Sr. No. 21 – 36)**		
Section A		**Section B**		**Section A**		**Section B**
Sr. No.	**Marks (60)**	**Marks (60)**		**Sr. No.**	**Marks (60)**	**Marks (60)**
1	2.5	4		**21**	7	9.5
2	28	-		**22**	-	4.5
3	9	0		**23**	6.5	8
4	7.5	2.5		**24**	7.5	0.5
5	4.5	-		**25**	1.5	0.5
6	11.5	-		**26**	6	5.5

7	3.5	12.5		**27**	3	7
8	4.5	17		**28**	-	10.5
9	0.5	10.5		**29**	2.5	20.5
10	9	3		**30**	5	2.5
11	4	0		**31**	4	22.5
12	5.5	6.5		**32**	4.5	5
13	3.5	2.5		**33**	7.5	11.5
14	6.5	5.5		**34**	3.5	5.5
15	1.5	3		**35**	4.5	8.5
16	13	2		**36**	3	-
17	0.5	5.5				
18	2	7		**Mean**	**5.788**	**6.484**
19	8	4		**SD**	**4.963**	**5.638**
20	-	0		**N**	**33**	**32**

The above Table 9 shows that the Mean Achievement score of students of Section A is 5.79 and that of Section B is 6.48. To check whether this difference in the Means is significant or not, the independent t-test was applied to check the hypothesis:

H_0: There is no significant difference between Mean Achievement scores of the students in Section A and Section B of class IX on Pretest with HOTS questions.

The result is presented in Table 10 below.

Table 10: Significance of difference between Mean Achievement Scores of Section A and Section B on Pretest

Group	N	M	SD	Df	T	Sig.(p value)	Remarks
Section A	33	5.79	5.6	32	0.53	0.60	NS
Section B	32	6.48	4.96	31			

The independent sample t-test table shown above indicates that the obtained ‘t’ value 0.53 is less than the table value 2.4 at 0.05 level ($p>0.05$) and hence it is not significant. It can be said that there is no significant difference between Section A and the Section B students in their Mean Achievement scores on Pretest. From the above analysis, it can be concluded that both the groups were almost at the same level of Achievement with respect to their ability to respond to HOTS questions on ‘Rational Numbers’. The equivalent groups A and B were left with thirty-three and thirty-two samples respectively.

During this process different sections (A and B) of the school were not disturbed. Sections A and B were randomly selected by using lottery method for experimental purpose. Section B got selected as the Control group and was taught by the Conventional method by school teacher. Section A got selected as the Experimental group, and was imparted the Instructional Package in 46 sessions. The final Posttest was conducted in both the sections at the end of the unit 'Real Numbers'. The Reaction scale was then given to students of Section A (Experimental group) to attain their feedback on the Instructional Package.

3.6 Methodology Adopted for the Study

Experimental method of research was adopted for the present Study. It is the most conclusive of scientific methods to establish cause-effect relationship. The cause variable is known as the independent variable and the effect variable the dependent variable. The independent variable is the influencing variable and the dependent variable is the influenced variable. In the present Study, 'the effective teaching strategies in Mathematics included in the Instructional Package' and 'the Conventional method of teaching Mathematics' acted as the cause and the achievement of the students in terms of 'scores' and 'Basic and Higher level competencies' acted as the effect.

As two conditions are needed to be satisfied to establish cause effect relationship, we need to have two groups for experimental studies; one to prove that wherever there is the cause there is the effect and the other to prove that wherever there is no cause there is no effect. Thus, two groups; one that proved the presence of effect with the presence of cause (Teaching strategies used in the Instructional Package) and one that proved that in the absence of cause (Teaching strategies used in the Instructional Package) there is no effect involved in the Study, termed as Experimental group and Control group respectively.

3.6.1 Research design used in the study

Research design is the blue print of the procedure adopted to conduct the research. True Experimental designs are the most powerful designs used in research, but cannot be employed in social sciences because the randomization of subjects to Experimental and Control groups is impossible and that a Control or Comparison group is unavailable, inconvenient or too expensive (Best & Kahn, 2012). In the present Study, the Equivalent-Posttest-Control Group design was used.

Equivalent-Posttest-Control Group Design

This design is very prevalent and useful in education, since it is often practically difficult to randomize subjects. The researcher in such occasions uses intact, already established groups of subjects, makes them equivalent statistically and then randomly selects

one of the groups for the experiment. In the present Study, the two class IX intact groups were made equivalent in terms of mean and standard deviation of some other variable (previous year Mathematics achievement scores) and then one of the group is randomly selected as the Experimental group and the other as Control group. According to Best and Kahn (2012), the Equivalent-Posttest-Control Group research design is one of the most potential Experimental design. It can be diagrammed as follows:

R X O_1

R Y O_1

R – indicates randomization of groups before the application of treatment

O_1 – indicates Posttest

X – indicates the Experimental group on which Blended method of teaching was applied

Y – indicates the Control group on which Conventional method of teaching was applied

- Advantage of this Design (Gay et al., 2009):

1. The combination of random assignment and the presence of a Control group serve to control for all threats to internal validity. Random assignment controls for regression and selection factors.
2. Randomization and the Control group control for maturation and the Control group controls for history, testing and instrumentation. Testing is controlled because if pretesting leads to higher Posttest scores, the advantage should be equal for both Experimental and the Control group.

3.6.2 Control to the threats of experimental validity for the present study

According to Best and Kahn (2012), the threats that can question the validity of an educational experiment can be classified into those that interfere with the internal validity and those with the external validity of the experiment. Internal validity of an experiment is ensured if the ‘experimental results’ are the consequence of the independent variable of the experiment alone and the external validity of an experiment is ensured if the ‘experimental results’ can be generalized to the target population.

In the present Study, threats to internal validity like ‘maturation’ of subjects, ‘history’ and ‘testing’ was controlled by randomizing the groups and having a Control group. Also the implementation phase of the treatment was limited to one and half month which helped in controlling the afore-mentioned threats. Subjecting the Control group to all the tests that were administered to Experimental group helped in minimizing the threat of ‘testing’. Instruments used in the present Study measured quantitative data in form of scores and not observable attributes. They were passed through the required verification processes before their

administration, thus the threat due to ‘unstable instrumentation’ was also dealt with. The Mathematics score of the Experimental and the Control group were subjected to the Shapiro-Wilks Normality test, which proved the normality of the sample, thus minimizing the threat to ‘statistical regression’. The randomization of the equivalent groups formed using the matching group technique helped to control the threat to ‘selection bias’. The threat of ‘interaction of selection and maturation’ was controlled by conducting the experiment on intact group with no choice given to the students to opt in or out of the experiment maintaining an overall normal distribution in terms of motivation of subjects. None of the subjects in either the Experimental or the Control group dropped out during the experiment, thus eliminating the threat of ‘experimental mortality’. The threat caused due to ‘experimenter bias’ was addressed to some extent by conducting the experiment on the students who were completely unknown to the researcher, with no previous knowledge regarding the them (Best & Kahn, 2012, p. 172 to 174).

The threats to external validity of the present Study of ‘interference of prior treatment’ and ‘artificiality of the experimental setting’ were controlled by conducting the experiment in real-life settings within intact classrooms with unmatched pedagogies and unshared learning materials between the Experimental and the Control group (Best & Kahn, 2012, p. 175). The Pretest used in the present Study with a purpose to verify the equivalence of the Experimental and the Control group for the construct – HOTS – was designed for concept other than ‘Real Numbers’ that was used in the Study. Thus the ‘interaction of testing’ was also taken care of. Due permission was taken from the Head of the Institution to conduct the experiment, thus, ensuring the necessary ethical protocols as well.

3.6.3 Stages of the experiment

The present Study aimed at finding the effectiveness of the Instructional Package that included effective teaching strategies over the Conventional method in Mathematics teaching. The Study was carried out in three stages. The details of the procedure adopted for the experiment are as follows:

Stage I: The first stage was the Pretest stage in which the students of both the Control group and the Experimental group were administered the Pretest. The Pretest scores were not used for Data analysis. They served to prove the equivalence of the Experimental and Control groups in terms of the construct of the Study: content specific higher order thinking skills.

Stage II: The second stage involved the conduction of the Experiment, i.e. teaching the content ‘Real Numbers’ through the effective teaching strategies and evaluations included in the Instructional Package to the Experimental group, and the Conventional method of

teaching to the Control group. After completion of seven sub-units, Evaluation 1 was administered. On completion of further seven sub-units, Evaluation 2 was administered to Experimental group. They were used as formative assessments.

Stage III: The third stage was the Posttest stage. In this stage, the students of the Control and the Experimental groups were Posttested on the entire unit.

The detailed design of the Study is presented in the following Figure 1:

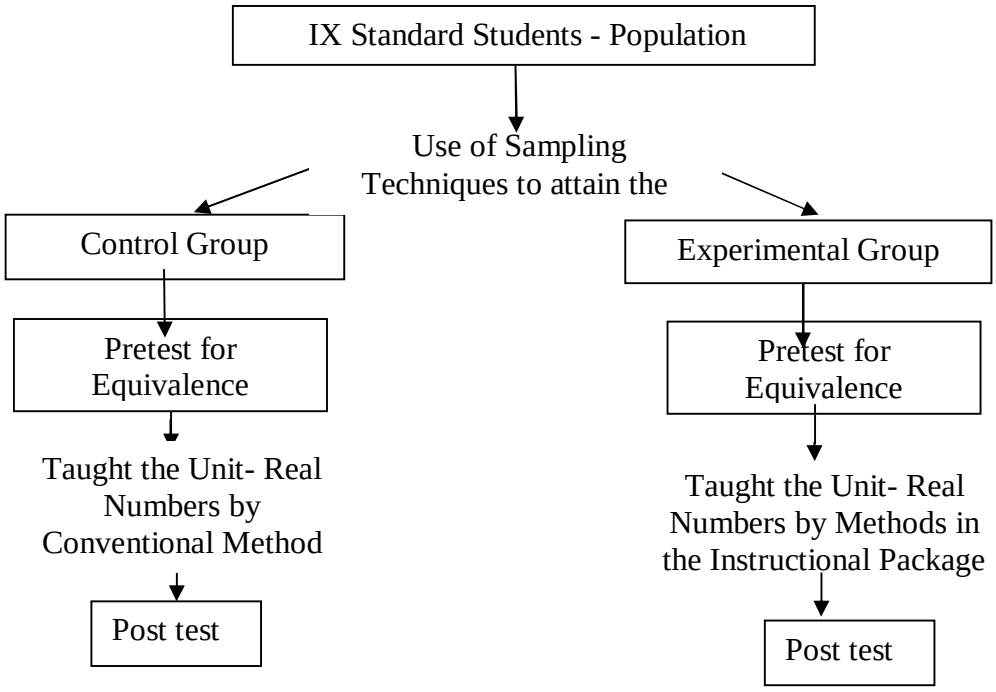


Figure 2: Design of the Study

3.6.4 Variables of the study

Variables are the condition or characteristics that the experimenter manipulates, controls or desires. The present Study involved independent and dependent variables.

1. Independent Variables

The present Study measured the effectiveness of the Instructional Package on the students' achievement scores and higher order thinking skills for the topic 'Real Numbers' in Mathematics, over the Conventional method of teaching Mathematics. Therefore, Independent variables are 'the effective teaching strategies in Mathematics included in the Instructional Package' and 'the Conventional method of teaching Mathematics'.

2. Dependent Variables

Dependent variables are the conditions or characteristics that appear, disappear or change as the experimenter introduces, removes or changes independent variable (Best & Kahn, 1995). Here student performance (achievement score) and higher order thinking skills

(Basic level and Higher level competencies) for the content ‘Real Numbers’ in Mathematics is the dependent variable.

3.6.5 Population of the study

The population of the Study consisted of all IX standard students of English medium schools of Vadodara city following the GSHSEB syllabus in the year 2017.

3.6.6 Sample of the study

Class IX students of one English medium school of Vadodara following the GSHSEB syllabus was selected purposively as sample for the Study. The selection of the school for this Study was done considering the readiness of the school to support the researcher in her endeavor and also the availability of the required resources and infrastructure which were crucial for the conduction of the Study. Seventy-two secondary students were selected as samples for the present Study. Out of which thirty-six students belonged to the Experimental group and thirty six belonged to the Control group.

3.6.7 Procedure for data collection

The present Study has two major aspects, one was the development of Instructional Package and another was to study the effectiveness of the developed Instructional Package over the Conventional method of teaching. The procedure for the development of Instructional Package has been described earlier. To study the effectiveness of the developed Instructional Package, the Posttest (described in Phase 1) was designed and administered at the end of the program to both groups. The Reaction scale (described in Phase 1) was administered to the Experimental group. Investigator assessed the Posttest responses as per the Scoring Rubric and got the Achievement Score and the Scores for the Basic level and Higher level competencies of each individual student of both the groups.

PHASE 3: PROCEDURE USED FOR ANALYSING THE DATA

3.7 Data Analysis Procedure Used to Check the Objective 3 and Reaction Scale

The data collected from the Posttest responses were analysed to study the effectiveness of the developed Instructional Package over the Conventional method of teaching. The investigator framed the following Objectives for the same:

Objective 3: To study the effectiveness of the developed Instructional Package over the Conventional method of teaching on the acquisition of higher order thinking skills in the content ‘Real Numbers’ in class IX students.

This was further studied with help of the following sub-objectives:

3.1 To study the effectiveness of the developed Instructional Package over the Conventional method of teaching on the acquisition of Higher level competencies in the content 'Real Numbers'.

3.2 To study the effectiveness of the developed Instructional Package over the Conventional method of teaching on the acquisition of Basic level competencies in the content 'Real Numbers'.

3.3 To study the effectiveness of the developed Instructional Package over the Conventional method of teaching in terms of the Mean Achievement scores for HOTS questions at specific levels - Comprehension, Application, Analysis, Synthesis and Evaluation in the content 'Real Numbers'.

3.4 To study the effectiveness of the developed Instructional Package over the Conventional method of teaching in terms of the Mean Achievement scores for HOTS questions including all levels in the content 'Real Numbers'.

The data collected from the Reaction Scale was used to find the reaction of the students on the Instructional Package and its implementation. The Objective thus framed was:

Objective 4: To study the reaction of students on the developed Instructional Package and its implementation.

In order to respond to the sub-objectives 3.1 and 3.2, the responses for each of the 15 Posttest questions of the students exposed to Instructional Package were compared to the respective responses of the students exposed to the Conventional method of teaching. The Investigator-made-Scoring Rubric for the Posttest, that described the Sample Responses for all the 15 questions and the basis on which each answer was scored for the Basic and the Higher level competencies, was used for this purpose [Appendix A (4)]. Each of the 15 responses of the 33 Experimental group students and 32 Control group students were checked. Number of students who scored 2, 1 and 0 for the Basic level competencies and 2, 1, and 0 for the Higher level competencies were recorded and each was converted into percentage and graphs to visualize the comparative data of the Experimental and the Control group.

The sub-objectives 3.3 and 3.4 were responded through the comparison of the final Posttest Achievement scores of the Experimental and the Control group, using 't' test.

The independent t-test was applied on the Posttest scores of the Experimental and the Control Group- Firstly, to check the effectiveness at individual cognitive levels: Comprehension, Application, Analysis, Synthesis and Evaluation; and Secondly, to check the effectiveness holistically at all levels- among the Control and Experimental group.

The responses of the students to the Reaction scale (Objective 4) were analysed using frequency and Intensity Index to further judge the effectiveness of the Instructional Package.

3.7.1 Rationale for using the 't' test for data analysis

In the present Study, the Independent t-test was used to establish the significance of the difference between the means of the Experimental and the Control group, on the Pretest- to establish equivalence and on the Posttest- to respond to Objectives 3.3 and 3.4 of the Study. Statistics applicable to a large group has been applied in the present Study as the sample size was more than thirty (32 in Control group and 33 in Experimental group).

The assumptions underlying Independent t-test as indicated by Seigel (1956) are:

(1) The data are independent of each other. In the present Study the scores of one set of participants is not systematically related to scores of the other participants.

(2) The populations must have the same variance (assumption of homogeneity). To meet this condition the Experimental and the Control group have been statistically matched. There are two techniques to match the groups: (a) Matching pair technique, in which matching is done initially by pairs and (b) Matching group technique, in the group as a whole is matched with the other group in terms of mean and standard deviation of some other variable than the one under study (Best & Kahn, 2012). The present Study employed the Matching group technique to form equivalent groups, as shown in Table 8. The equivalent groups were then randomly selected as the Experimental and the Control group.

(3) The test variable is normally distributed within each of the two populations. In the present Study, the previous year's (class VIII) achievement scores in Mathematics of the Experimental and the Control group were subjected to the Shapiro-Wilks Normality test, whose result is tabulated below in Table 11.

Table 11: Shapiro-Wilks Normality Test on VIII Class Achievement Scores of Experimental and Control Group

Group	SS	B	W	p-value	∝-value
Experimental	7537.332	85.167	0.9623	0.4123	0.05
Control	7996.305	86.316	0.9317	0.06	0.05

The above table shows that the obtained p-value 0.4123 is greater than the ∝-value 0.05, in case of the Experimental group. Also, the obtained p-value 0.06 is greater than the ∝-value 0.05. Thus, the assumption of normality has been met for both the samples.

Thus, all the conditions to apply 't' test on the data obtained from the Experimental and Control group has been satisfied. In case of any discrepancy it is to be noted that the 't' test

for independent groups may be used without appreciable error despite moderate violations of the normality and/or the homogeneity of variance assumptions (Pagano, 2007, p. 339). Sample sizes can be considered equal if the larger group is not more than one and half times larger than the smaller group (Morgan et al., 2013). Only if the variance is 4 to 5 times larger than the variance in the other group, then the assumption of homogeneity cannot be considered (Tabachnick & Fidell, 2007).

In the present Study two-tailed 't' test has been applied using a significance level of 0.05. The two-tailed test allots half of the alpha to test the statistical significance in one direction and half of the alpha to test statistical significance in the other direction of interest – in this case 'whether there is a significant difference in the abilities of the students to respond to HOTS questions.'

After detailing out the development process of the Instructional Package, the tools and the methodology adopted to implement the Study, the next Chapter presents the Lesson plans, the Worksheets and the Assessment sheets created by the investigator as a part of the Instructional Package and the Schedule of implementation of the Instructional Package.