# CHAPTER 5

## DATA ANALYSIS AND INTERPRETATION

# CHAPTER V

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## 5.0 Introduction

The present Study was intended to test the effect of the Instructional Package on the students' abilities to respond to higher order thinking questions for the content Real Numbers of Mathematics of class IX. In the previous sections the approach used to collect data for the Study was described in detail. The present Chapter is devoted to the analysis and the interpretation of the collected data according to the objectives and the hypothesis of the present Study formulated in Chapter 1. The major objectives of the present Study are the development of Instructional Package; implementing it; and studying its effectiveness in terms of students' test scores in the Achievement test, their Basic and Higher level competencies, and their personal responses about the developed Instructional Package in the Reaction scale. This Chapter presents the analysis of the data collected and its results.

## 5.1 Description of Analysis in Brief

An experimental research was conducted to examine the effect of Instructional Package on achievement and higher order thinking for the content Real Numbers in Mathematics of IX standard students. The sample consisted of 72 ninth standard students belonging to two sections of a school in Vadodara following the GSHSEB syllabus. Before starting the actual experiment, the investigator had to ensure that the two groups selected for the Study were equalized with respect to major controlling variables. So, the investigator got the VIII standard achievement scores of the 72 sample students from the school authorities and used statistical measures to equate the two intact groups with respect to their means and standard deviation; thus, getting two equivalent matched groups, one with 33 samples and the other with 32 samples. One of the groups was then randomly selected as the Experimental group and the other as the Control group. Both the groups were administered Pretest before providing the instructions on the content Real Numbers to prove equivalence of both the groups. The Experimental group was provided with Instructional Package as treatment and the other group was kept under controlled condition by providing instruction through the Conventional method. After a total of forty-eight sessions of 40 minutes each, the Posttest was administered to the Experimental and the Control group.

The Posttest was designed with HOTS questions of comprehension, application, analysis, synthesis and evaluation levels. A Scoring Rubric was designed accordingly for the Posttest which was used to score the responses for the Basic level and Higher level

competencies. It served the purpose of finding the effectiveness of Instructional Package on the Experimental group over the Control group in terms of Basic level and Higher level competencies, using frequency and percentage. The Independent t-test was used to compare the Experimental and the Control group on the Achievements for each cognitive levels - Comprehension, Application, Analysis, Synthesis and Evaluation. The overall Posttest scores were also subjected to Independent t-test to serve the purpose of finding the effectiveness of Instructional Package on the Achievement of the Experimental group over the Control group. The Reaction scale responses were analysed using, frequency and Intensity Index.

The details of the analysis done on the different set of scores are presented in two stages.

**Stage I: Analysis of the Posttest**

**Stage II: Analysis of Reaction Scale**

**5.2 Description of Analysis and Interpretation at Stage I**

Stage I includes the analysis and interpretation of the data obtained from Posttest, after the implementation of the Instructional Package on the Experimental group and the Conventional method of teaching on the Control group. The analysis for

**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' was bifurcated into four 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'.

In order to respond to the sub-objective 3.1 and 3.2, the responses for each of the fifteen 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.

### 5.2.1 Analysis of the Posttest responses for competencies (sub-objectives 3.1 and 3.2)

Responses to the questions in the Posttest were analyzed to evaluate the acquisition of Higher level and Basic level competencies of the students. A Scoring Rubric for the Posttest was developed that described the Sample Responses for all the fifteen questions. It also elaborated the basis on which each answer was scored for the Basic and the Higher level competencies. Using this Rubric, each of the fifteen responses of the 33 Experimental group students and 32 Control group students were checked. Number of students who scored 2, 1 and 0 at the Basic level and 2, 1, and 0 at the Higher level were recorded and each converted into percentage and graphs to visualize the comparative data of the Experimental and the Control group. The general interpretation of the Basic level and Higher level scores 2, 1, and 0 is tabulated as:

**Table 13: Interpretation of Basic level Scores**

| Scores | Interpretation of Basic Level Scores |
|---|---|
| **2 points** | • Correct and Complete Computations<br>Correct identification and application of concepts, theories and rules<br>Correct calculations (application of mathematical operations)<br>Correct algorithmic procedure used |
| **1 point** | • Partially Correct/Incomplete Computations |
| **0 point** | • Incorrect or No Computations |

**Table 14: Interpretation of Higher level Scores**

| Scores | | Interpretation of Higher Level Scores |
|---|---|---|
| **Comprehension** | **2** | Correct - understanding of information, grasping of meaning, interpretation of facts, compare, contrast, order, group |
| | **1** | Partially correct - understanding of information, grasping of meaning, interpretation of facts, compare, contrast, order, group |
| | **0** | Incorrect/No – above stated competency |
| **Application** | **2** | Correct -use of information, use of methods, concepts, theories in new situations to solve problems or make inferences. |
| | **1** | Partially correct- use of information, use of methods, concepts, theories in new situations to solve of problems or make inferences. |
| | **0** | Incorrect/No - above stated competency |
| **Analysis** | **2** | Correct - identification of components, organisation of the components, recognition of hidden meaning to solve problem |
| | **1** | Partially correct - identification of components, organisation of the components, recognition of hidden meaning to solve problem |
| | **0** | Incorrect/No - above stated competency |
| **Synthesis** | **2** | Correct - use old ideas to create new ones, generalize from given facts, relate knowledge from several areas, and draw conclusions |
| | **1** | Partially correct - use old ideas to create new ones, generalize from given facts, relate knowledge from several areas, and draw conclusions |
| | **0** | Incorrect/No - above stated competency |
| **Evaluation** | **2** | Correct - comparison and discrimination between ideas, making choices based on reasoned argument and verification of value |
| | **1** | Partially correct - comparison and discrimination between ideas, making choices based on reasoned argument and verification of value |
| | **0** | No or incorrect - above stated competency |

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

#### 5.2.1.1 Question-wise analysis of the Posttest responses for competencies

Each question of the Posttest was analyzed to find the Basic level and the Higher level scores, based on which the number of students attaining respective scores i.e. 2, 1 or 0 at Basic level and 2, 1, 0 at the Higher level was recorded and converted into percentage. This process was done for both the Experimental group and the Control group. Analysis of each question is represented with three tables. Table (a) show Scoring Rubric for the respective question, Table (b) show Samples of students' work and Method used to award the scores and Table (c) shows the Comparative Percentages of the Basic level and Higher level competencies achieved completely; partially; or none; for the Experimental and the Control groups. Sample answers for each Posttest question is attached in the Appendix A (4)

**1. Analysis of Question 1 – Comprehension level**

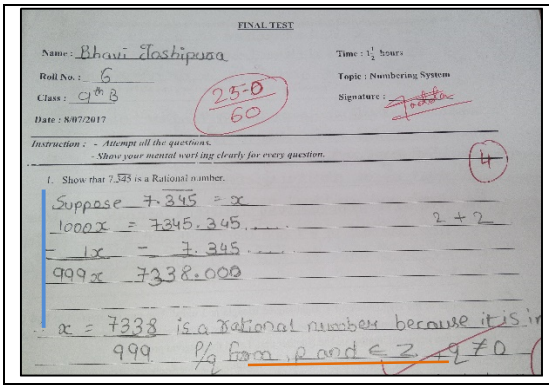
Q1. Show that $7.\overline{345}$ is a Rational number.

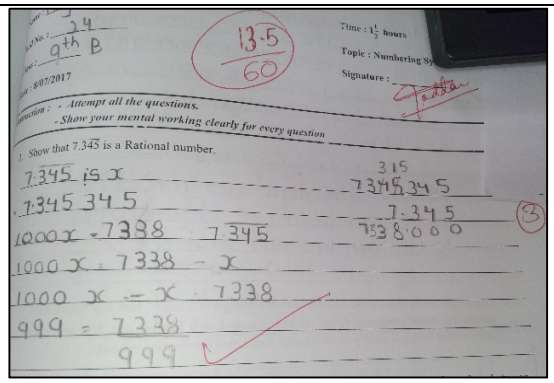
**Table 15: Analysis of Posttest Question 1**

**(a) Scoring Rubric for Question 1**

| Scoring for Basic level | | Scoring for Higher level | |
|---|---|---|---|
| 2 | Correct & complete computation | 2 | Grasping the holistic meaning and displaying it with complete description of the definition of Q |
| 1 | Partially correct/incomplete comp. | 1 | Partial explanation of the above |
| 0 | Incorrect or no computation | 0 | Incorrect or no skills (above) displayed |

**(b) Sample of Student Response and Scoring for Question 1**




| | |
|---|---|
| **2 points** (Basic) for computations.<br>**2 points** (Higher) for grasping the meaning that the decimal no. needs to be shown as fraction and justify it with the definition. | **2 points** (Basic) for computations.<br>**1 point** (Higher) for grasping the meaning that the decimal no. needs to be shown as fraction. |

**(c) No. of Students who achieved Basic and Higher level competencies in Q.1**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 78.8 | 42.4 | 46.8 | 6.2 |
| **1** | 3.2 | 42.4 | 25.2 | 62.5 |
| **0** | 18 | 15.2 | 28 | 31.3 |

The above Table indicates that with respect to ***Question 1 (Basic level),***

78.8% of the students of the Experimental group did correct and complete computations; while 46.8% of the students of the Control group did correct and complete computations.

3.2% of students of the Experimental group did partially correct/incomplete computations; while 25.2% of the students in Control group did partially correct/incomplete computations.

18% of the students of the Experimental group did incorrect/no computations; while 28% of students of the Control group did incorrect/no computations.

With respect to ***Question 1 (Higher level)***,

42.4% of the students of the Experimental group grasped the holistic meaning of the concept and gave proper mathematical reasoning; while 6.2% of the students of the Control group grasped the holistic meaning of the concept and gave proper mathematical reasoning.

42.4% of the students of the Experimental group could display the respective Higher level competency partially; while 62.5% of the students of the Control group could display the respective Higher level competency partially.

15.2% of the students of the Experimental group did not show the respective Higher level competency; while 31.3% of the students of the Control group did not show the respective Higher level competency.

**2. Analysis of Question 2 - Comprehension level**

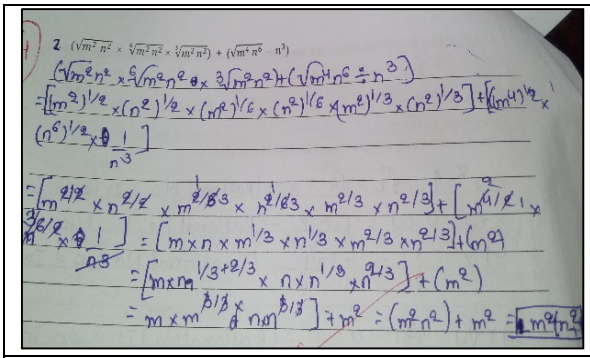
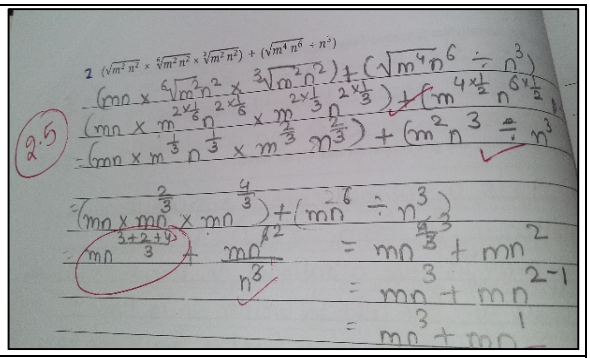
Q2. Simplify :$(\sqrt{m^2\ n^2} \times \sqrt[6]{m^2\,n^2} \times \sqrt[3]{m^2\,n^2})\ +\ (\sqrt{m^4 n^6}\ \div n^3$

**Table 16: Analysis of Posttest Question 2**

**(a) Scoring Rubric for Question 2**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | Correct and complete computations with respect to basic exponential rules | 2 | Correct ordering, grouping of exponential functions and differentiating between mathematical and exponential operation |
| 1 | Partially correct /incomplete computations with respect to basic exponential rules | 1 | Partial ordering, grouping and differentiating of the same |
| 0 | Incorrect/no computation | 0 | Incorrect or no (above) skills displayed |

**(b) Sample of Student Response and Scoring for Question 2**

| | |
|---|---|
|  |  |
| **2 points** (Basic) for correct identification of exponential rules and doing correct - complete computation.<br>**2 points** (Higher) for correctly ordering and grouping exponential functions and differentiating between mathematical and exponential operation. | **1.5 points** (Basic) for correct identification of exponential rules but error in application of mathematical operations.<br>**1 point** (Higher) for correctly differentiating between the mathematical and exponential operations. Error in grouping. |

**(c) No. of Students who achieved Basic and Higher level competencies in Q.2**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 45.5 | 28 | 22 | 6.2 |
| **1** | 18 | 18 | 25 | 12.6 |
| **0** | 36.5 | 54 | 53 | 81.2 |

The above Table indicates that with respect to ***Question 2 (Basic level)***,

45.5% of the students in the Experimental group did correct and complete computations with respect to basic exponential rules; while 22% of the students of the Control group did correct and complete computations with respect to basic exponential rules.

18% of students of the Experimental group did partially correct/incomplete computations with respect to basic exponential rules; while 25% of the students of Control group did partially correct/incomplete computations with respect to basic exponential rules.

36.5% of the students of the Experimental group did incorrect/no computations; while 53% of students of the Control group did incorrect/no computations.

With respect to ***Question 2 (Higher level)***,

28% of the students of the Experimental group correctly ordered, grouped exponential functions and differentiated between mathematical and exponential operations; while 6.2% of the students of the Control group correctly ordered, grouped exponential functions and differentiated between mathematical and exponential operations.

18% of the students of the Experimental group could display the Higher level competency partially; while 12.6% of the students of the Control group could display the Higher level competency partially.

54% of the students of the Experimental group did not show the respective Higher level competency, while 81.2% of the students of the Control group did not show the respective Higher level competency.

**3. Analysis of Question 3 - Comprehension level**

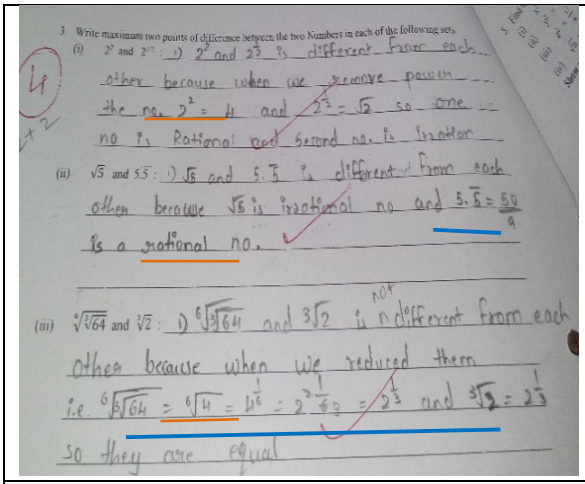
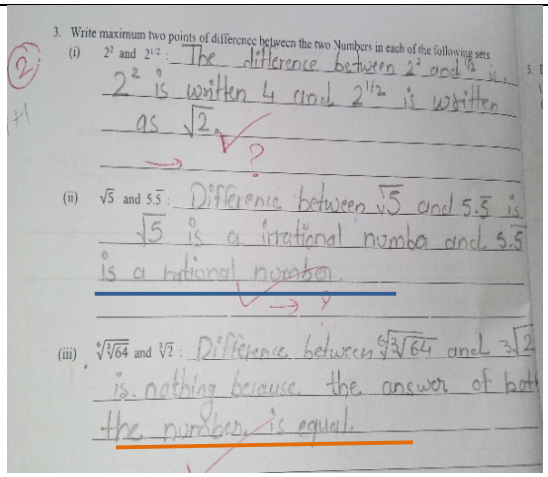
Q3. Write maximum two points of difference between the two Numbers in each of the following sets. (i) $2^2$ and $2^{1/2}$ (ii) $\sqrt{5}$ and $5.\overline{5}$ (iii) $\sqrt[6]{\sqrt[3]{64}}$ and $\sqrt[3]{2}$

**Table 17: Analysis of Posttest Question 3**

**(a) Scoring Rubric for Question 3**

| Scoring for Basic level | | Scoring for Higher level | |
|---|---|---|---|
| 2 | Correct and complete computations and identification of Rational and Irrational number | 2 | Correct understanding of - given information, interpretation of facts after comparing & contrasting and justifying the same with mathematical reasoning |
| 1 | Partially correct/incomplete computations and identification of Rational and Irrational number | 1 | Partially correct understanding of - given information, interpretation of facts after comparing & contrasting and justifying the same with mathematical reasoning |
| 0 | Incorrect/no computations, identification | 0 | Incorrect or no (above) skill displayed |

**(b) Sample of Student Response and Scoring for Question 3**

| | |
|---|---|
|  |  |
| **2 points** (Basic) for correct computations and identification of Rational and Irrational number.<br>**2 points** (Higher) for correct understanding of - given numerical information, interpretation of facts (Rational/Irrational) after comparing & contrasting (computations) and justifying the same with mathematical reasoning. | **1 point** (Basic) for partially done computations and partial recognition of Rational/Irrational number.<br>**1 point** (Higher) for partial interpretation of facts (Rational/Irrational) and for mathematical reasoning without showing relevant computations. |

**(c) No. of Students who achieved Basic and Higher level competencies in Q.3**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 24.3 | 12 | 6.2 | 3 |
| **1** | 60.7 | 51.5 | 50 | 22 |
| **0** | 15 | 36.5 | 43.8 | 75 |

The above table indicates that with respect to ***Question 3 (Basic level)***,

24.3% of the students of the Experimental group did correct and complete computations and could identify Rational and Irrational numbers; while 6.2% of the students of the Control group did correct and complete computations and could identify Rational and Irrational numbers.

60.7% of students of the Experimental group did partially correct/incomplete computations and made some errors in identifying the Rational and Irrational numbers; while 50% of the students of the Control group did partially correct/incomplete computations and made some errors in identifying the Rational and Irrational numbers.

15% of the students of the Experimental group did not show the respective Basic level competency; while 43.8% of students of the Control group did not show any respective Basic level competency.

With respect to ***Question 3 (Higher level)***,

12% of the students of the Experimental group displayed correct understanding of given information, interpreted the facts after comparing & contrasting and justified the same with mathematical reasoning; while 3% of the students of the Control group displayed correct understanding of given information, interpreted the facts after comparing & contrasting and justified the same with mathematical reasoning.

51.5% of the students of the Experimental group could display the respective Higher level competency partially; while 22% of the students of Control group could display the respective Higher level competency partially.

36.5% of the students of the Experimental group did not show the respective Higher level competency; while 75% of the students of the Control group did not show the respective Higher level competency.

**4. Analysis of Question 4 - Application level**

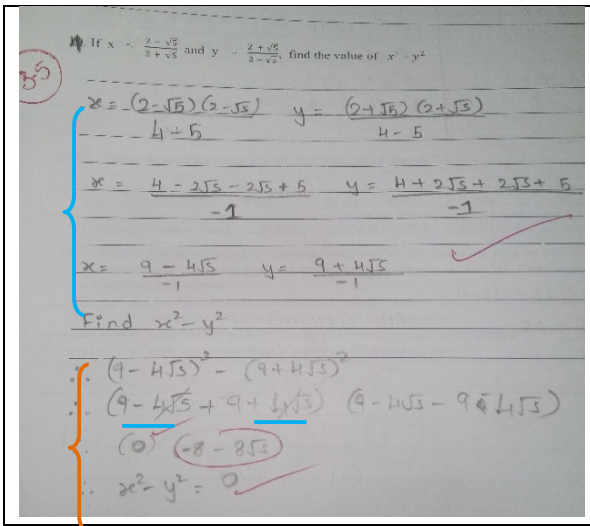
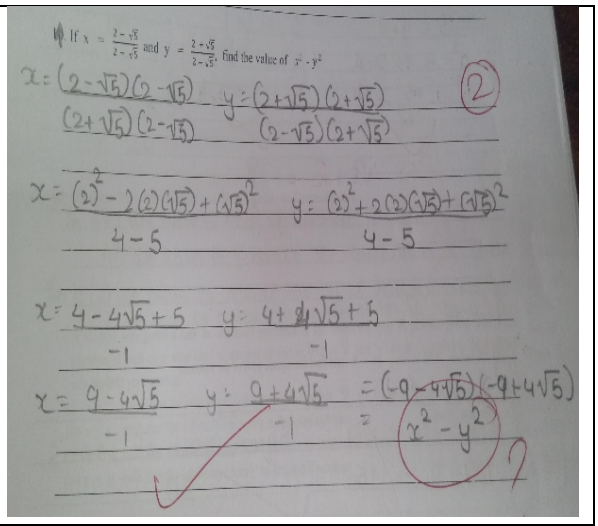
Q4. If $x = \frac{2-\sqrt{5}}{2+\sqrt{5}}$ and $y = \frac{2+\sqrt{5}}{2-\sqrt{5}}$, find the value of $x^2 - y^2$.

**Table 18: Analysis of Posttest Question 4**

**(a) Scoring Rubric for Question 4**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | Correct and complete computations (operations on Real numbers): Values of x and y. | 2 | Correct use of the information (Operations on Real numbers) in a different context 'Algebra': use of algebraic identity to solve the problem. |
| 1 | Partially correct/incomplete computations (operations on Real numbers) | 1 | Partially correct use of the given information to solve the problem |
| 0 | Incorrect or no computations (Operations on Real numbers) | 0 | Incorrect or no use of information to solve the problem |

**(b) Sample of Student Response and Scoring for Question 4**

| | |
|---|---|
|  |  |
| **1.5 point** (Basic) for correct procedure used to find the values of x and y bur minor errors in computations of the values of x and y, but error in the final step.<br>**2 point** (Higher) for correct use of 'operation of real numbers' in a different context 'algebra': use of algebraic identity to find solution. | **2 points** (Basic) for correct procedure and computation for the values of x and y.<br>**0 point** (Higher) for no use of the learnt concept in a different context. |

**(c) No. of Students who achieved Basic and Higher level competencies in Q.4**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 46 | 12.5 | 12.5 | 3 |
| **1** | 30 | 24.5 | 30 | 12.2 |
| **0** | 24 | 63 | 57.5 | 84.8 |

The above table indicates that with respect to ***Question 4 (Basic level)***,

46% of the students in the Experimental group did correct and complete computations that involved operations on Real numbers; while 12.5% of the students of the Control group did correct and complete computations that involved operations on Real numbers.

30% of students of the Experimental group did partially correct/incomplete computations; while 30% of the students in Control group did partially correct/incomplete computations.

24% of the students of the Experimental group did not show the respective Basic level competency; while 57.5% of students of the Control group did not show the respective Basic level competency.

With respect to ***Question 4 (Higher level)***,

12.5% of the students of the Experimental group correctly used the information to solve the problem; while 3% of the students of the Control group correctly used the information to solve the problem.

24.5% of the students of the Experimental group displayed the respective Higher level competency partially; while 12.2% of the students of the Control group could display the respective Higher level competency partially.

63% of the students of the Experimental group did not show the respective Higher level competency; while 84.8% of the students of the Control group did not show the respective Higher level competency.

**5. Analysis of Question 5 – Application Level**

Q5. Find whether the variables x, y, z and u represent a Rational number, Irrational number or both : (i) $x^2 = 9$ (ii) $y^2 = 0.04$ (iii) $z^2 = \frac{17}{4}$ (iv) $\sqrt{u} = \sqrt{81}$

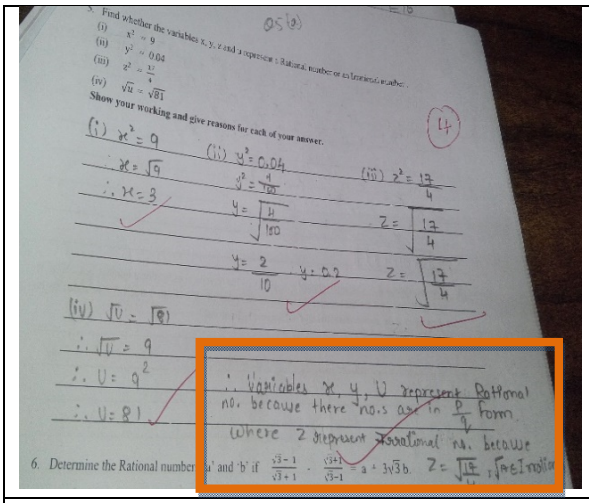
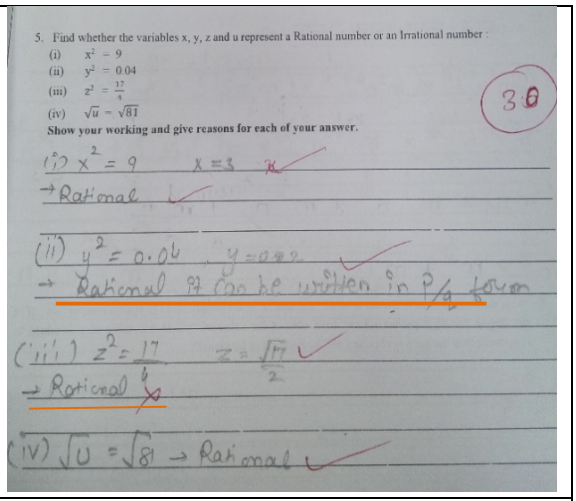
Show your working and give reasons for each of your answer.

**Table 19: Analysis of Posttest Question 5**

**(a) Scoring Rubric for Question 5**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | Correct and complete computation of values of x, y, z and u. | 2 | Correct use of - the concept of square root and property of Rational and Irrational numbers to make inference. |
| 1 | Partially correct/incomplete computation of values of x, y, z and u. | 1 | Partially correct use of -the concept of square root and property of Rational and Irrational numbers to make inference. |
| 0 | Incorrect or no computations. | 0 | Incorrect or no use of the concepts to make inferences. |

**(b) Sample of Student Response and Scoring for Question 5**

| | |
|---|---|
|  |  |
| **2 points** (Basic) for correct and complete computation of values of x, y, z and u.<br>**2 points** (Higher) for correct use of - the concept of square root and property of Rational and Irrational numbers to make inference. | **2 points** (Basic) for correct and complete computation of values of x, y, z and u.<br>**1 point** (Higher) for partial identification: Rational numbers only with proper justification for the same and not for Irrational numbers. |

**(c) No. of Students who achieved Basic and Higher level competencies in Question 5**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 29.2 | 13 | 12.5 | 0 |
| **1** | 54.8 | 45 | 59.3 | 28.2 |
| **0** | 16 | 42 | 28.2 | 71.8 |

The above table indicates that with respect to ***Question 5 (Basic level)***,

29.2% of the students in the Experimental group did correct and complete computations; while 12.5% of the students of the Control group did correct and complete computations.

54.8% of students of the Experimental group did partially correct/incomplete computations; while 59.3% of the students in Control group did partially correct/incomplete computations.

16% of the students of the Experimental group did not display the respective Basic level competency; while 28.2% of the students of the Control group did not display the respective Basic level competency.

With respect to ***Question 5 (Higher level)***,

13% of the students of the Experimental group correctly used the concept of square roots and properties of Real numbers in new situation; while 0% of the students of the

Control group correctly used the concept of square roots and properties of Real numbers in new situation.

45% of the students of the Experimental group could display the respective Higher level competency partially; while 28.2% of the students of the Control group could display the respective Higher level competency partially.

42% of the students of the Experimental group did not show the respective Higher-level competency; while 71.8% of the students of the Control group did not show the respective Higher-level competency.

**6. Analysis of Question 6 – Application Level**

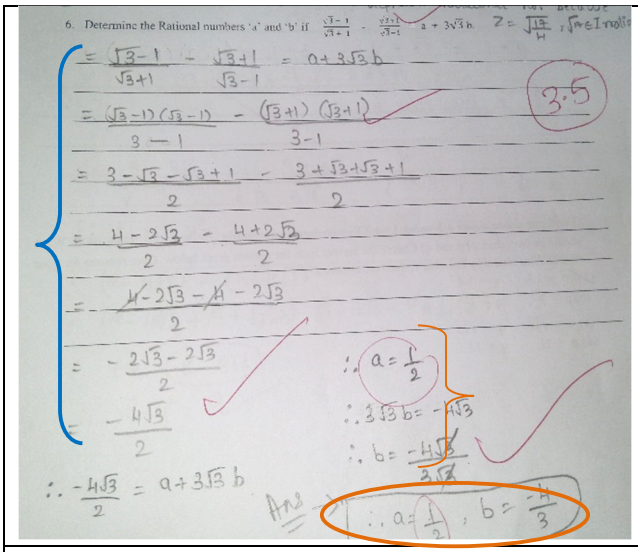
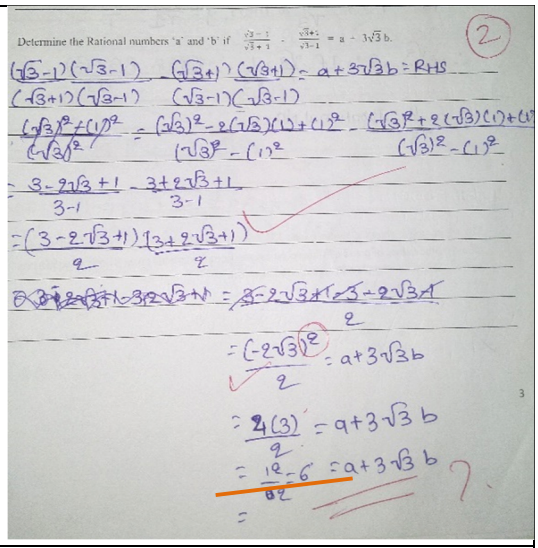
Q6. Determine the Rational numbers 'a' and 'b' if $\frac{\sqrt{3}-1}{\sqrt{3}+1} - \frac{\sqrt{3}+1}{\sqrt{3}-1} = a + 3\sqrt{3}\,b$

**Table 20: Analysis of Posttest Question 6**

**(a) Scoring Rubric for Question 6**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | Correct and complete computation of LHS | 2 | Correct use of the concept of the algebraic property of equating like terms on both sides of an equation to find values of 'a' and 'b', (application of R in different context). |
| 1 | Partially correct/incomplete computations | 1 | Partially correct use of the information to solve new problem |
| 0 | Incorrect/ no computations | 0 | Incorrect or no use of information to solve new problem |

**(b) Sample of Student Response and Scoring for Question 6**

| | |
|---|---|
|  |  |
| **2 points** (Basic) for correct computations and procedures involving 'operations on Real numbers' to solve LHS.<br>**1.5 points** (Higher)for using algebraic property of equating like terms on both sides of an equation correctly for 'b', but making an error for 'a' | **1.5 points** (Basic) for correct procedure but a minor error in computation in the last step.<br>**0.5 point** (Higher) aware ofconcept of equality but no use of the algebraic property to find values of 'a' and 'b' |

**(c) No. of Students who achieved Basic and Higher level competencies in Question 6**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 40.6 | 15.6 | 3 | 0 |
| **1** | 34.4 | 31.3 | 21.8 | 6.3 |
| **0** | 25 | 53.1 | 75.2 | 93.7 |

The above table indicates that with respect to **Question 6 (Basic level)**,

40.6% of the students in the Experimental group did correct and complete computations; while 3% of the students of the Control group did correct and complete computations.

34.4% of students of the Experimental group did partially correct/incomplete computations; while 21.8% of the students in Control group did partially correct/incomplete computations.

25% of the students of the Experimental group did not display the respective Basic level competency; while 75.2% of students of the Control group did not display the respective Basic level competency.

With respect to ***Question 6 (Higher level)***,

15.6% of the students of the Experimental group correctly used the information to solve the problem (finding values of 'a' and 'b') in new context; while 0% of the students of the Control group correctly used the information to solve the problem (finding values of 'a' and 'b') in new context.

31.3% of the students of the Experimental group could display the respective Higher level competency partially; while 6.3% of the students of the Control group could display the respective Higher level competency partially.

53.1% of the students of the Experimental group did not show the respective Higher level competency; while 93.7% of the students of the Control group did not show the respective Higher level competency.

**7. Analysis of Question 7 – Analysis Level**

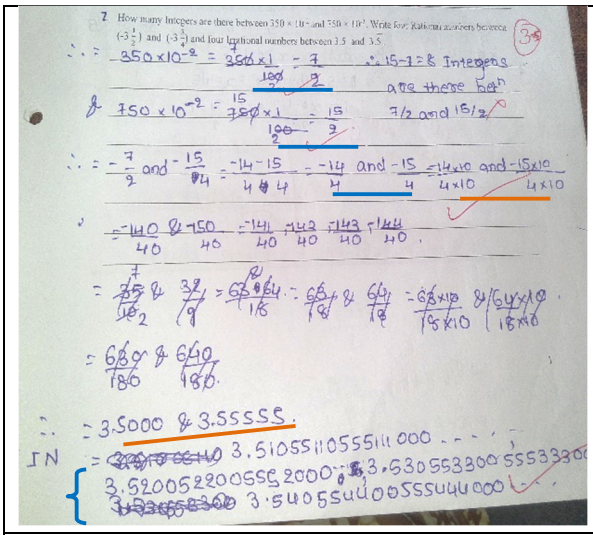
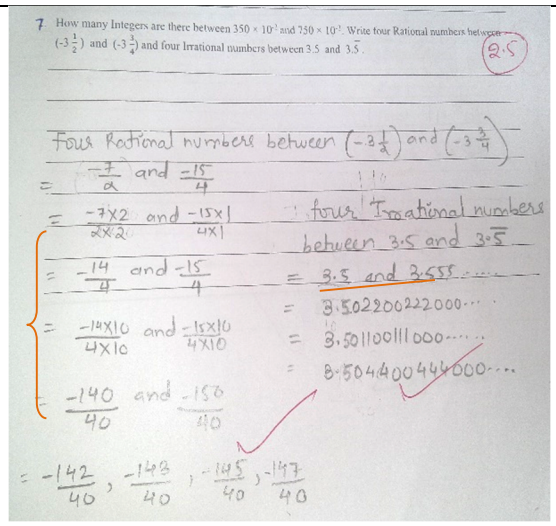
Q7. How many Integers are there between $350 \times 10^{-2}$ and $750 \times 10^{-2}$. Write four Rational numbers between $(-3\frac{1}{2})$ and $(-3\frac{3}{4})$ and four Irrational numbers between 3.5 and $3.\overline{5}$.

**Table 21: Analysis of Posttest Question 7**

**(a) Scoring Rubric for Question 7**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | Correct and complete calculation (decimal values of (i)) and algorithmic procedure followed in (ii) and (iii) | 2 | Recognition of the components [ (i) values 3.5 and 7.5, (ii) -3.5 and -3.75 or equivalent fractions, (iii) 3.5000… and 3.5555…] Organizing them & using the hidden meaning [(i) sequencing nos. between 3.5 and 7.5 and picking out the Integers to be counted, (ii) identifying the hidden meaning and sequencing in the form of decimal nos. or equivalent fractions] |
| 1 | Partially correct/incomplete computation | 1 | Partial recognition, organization of components, and identification of hidden meanings to solve. |
| 0 | Incorrect or no computations and algorithmic procedure | 0 | Incorrect or no recognition, organization of components, and identification of hidden meanings to solve. |

**(b) Sample of Student Response and Scoring for Question 7**

| | |
|---|---|
|  |  |
| **2 points** (Basic) for correct computations in (i) and procedure followed for (ii) and (iii).<br>**1 point** (Higher) for (ii) converting to appropriate equivalent fractions and in (iii) differentiating 3.5 from 3.555… | **1.5 points** (Basic) for correct procedure followed (ii) and (iii).<br>**1 point** (Higher) for (ii) converting to appropriate equivalent fractions and in (iii) differentiating 3.5 from 3.555… |

**(c) No. of Students who achieved Basic and Higher level competencies in Q. 7**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 25.8 | 16.2 | 9.4 | 3.1 |
| **1** | 51.6 | 29 | 40.6 | 18.8 |
| **0** | 22.6 | 54.8 | 50 | 78.1 |

The above table indicates that with respect to ***Question 7 (Basic level)***,

25.8% of the students in the Experimental group did correct and complete computations; while 9.4% of the students of the Control group did correct and complete computations.

51.6% of students of the Experimental group did partially correct/incomplete computations; while 40.6% of the students of the Control group did partially correct/incomplete computations.

22.6% of the students of the Experimental group did not display the respective Basic level competency; while 50% of students of the Control group did not display the respective Basic level competency.

With respect to ***Question 7 (Higher level)***,

16.2% of the students of the Experimental group could correctly identify the hidden meaning and see the pattern; while 3.1% of the students of the Control group could correctly identify the hidden meaning and see the pattern.

29% of the students of the Experimental group could display the respective Higher level competency partially; while 18.8% of the students of the Control group could display the respective Higher level competency partially.

54.8% of the students of the Experimental group did not display the respective Higher level competency; while 78.1% of the students of the Control group could not display the respective Higher level competency.

**8. Analysis of Question 8 – Analysis Level**

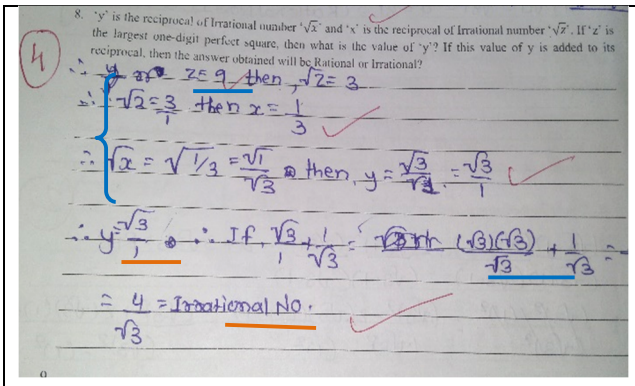
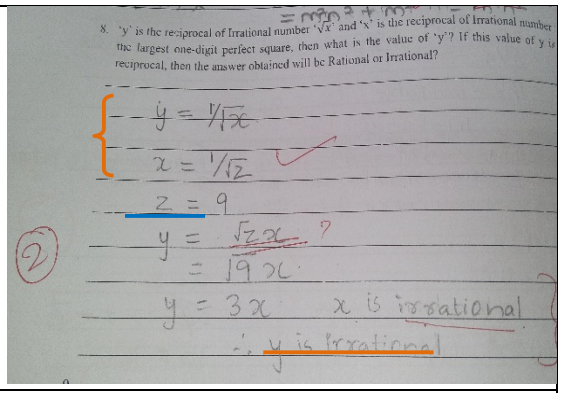
Q 8. 'y' is the reciprocal of Irrational number '$\sqrt{x}$' and 'x' is the reciprocal of '$\sqrt{z}$'. If 'z' is the largest one-digit perfect square, then what is the value of 'y'? If this value of y is added to its reciprocal, then the answer obtained will be Rational or Irrational.

**Table 22: Analysis of Posttest Question 8**

**(a) Scoring Rubric for Question 8**

| Scoring for Basic level | | Scoring for Higher level | |
|---|---|---|---|
| 2 | Correct use of previous knowledge in computing reciprocals and mathematical operations | 2 | Correct identification of components x, y, z and organizing them appropriately to infer value of y and y + 1/y |
| 1 | Partially correct use of computing reciprocals and mathematical operations | 1 | Partially correct identification of components x, y, z and organizing them appropriately to infer value of y and y + 1/y |
| 0 | Incorrect or no use of computing reciprocals and mathematical operations | 0 | Incorrect or no identification of components x, y, z and organizing them appropriately to infer value of y and y + 1/y |

**(b) Sample of Student Response and Scoring for Question 8**

| | |
|---|---|
|  |  |
| **2 points** (Basic) for correct use of previous knowledge in computing reciprocals and value of z.<br>**2 points** (Higher) for correct identification of components x, y, z and organizing them appropriately to infer value of y and y + 1/y. | **1 point** (Basic) for correct value of z and partially correct use of reciprocal.<br>**1 point** (Higher) for identification of components y and x and infering the value of y as an Irrational number (correct reasoning). |

**(c) No. of Students who achieved Basic and Higher level competencies in Question 8**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 19.4 | 6.5 | 0 | 0 |
| **1** | 19.4 | 12.9 | 18.8 | 0 |
| **0** | 61.2 | 80.6 | 81.2 | 100 |

The above table indicates that with respect to ***Question 8 (Basic level)***,

19.4% of the students in the Experimental group did correct and complete computations; while 0% of the Control group did correct and complete computations.

19.4% of students of the Experimental group did partially correct/incomplete computations; while 18.8% of the students of the Control group did partially correct/incomplete computations.

61.2% of the students of the Experimental group did incorrect/no computations; while 81.2% of students of the Control group did incorrect/no computations.

With respect to ***Question 8 (Higher level)***,

6.5% of the students of the Experimental group could identify the components x, y, z and organize them appropriately to infer value of y and y + 1/y; while 0% of the students of the Control group could identify the components x, y, z and organize them appropriately to infer value of y and y + 1/y.

12.9% of the students of the Experimental group could display the respective Higher level competency partially; while 0% of the students of the Control group could display the respective Higher level competency partially.

80.6% of the students of the Experimental group did not show the respective Higher level competency; while 100% of the students of the Control group did not show the respective Higher level competency.

**9. Analysis of Question 9 – Analysis Level**

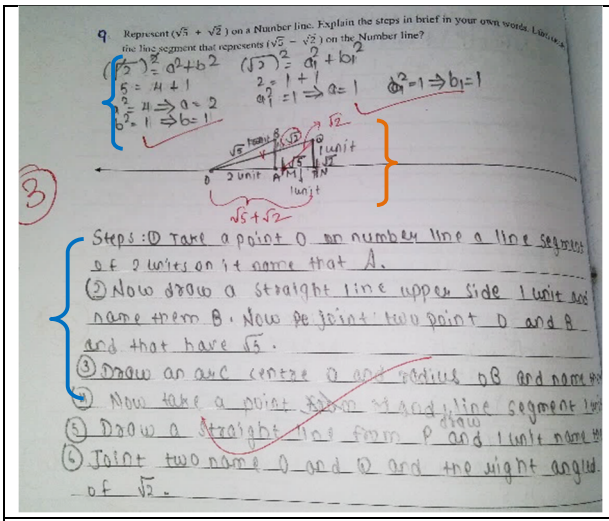
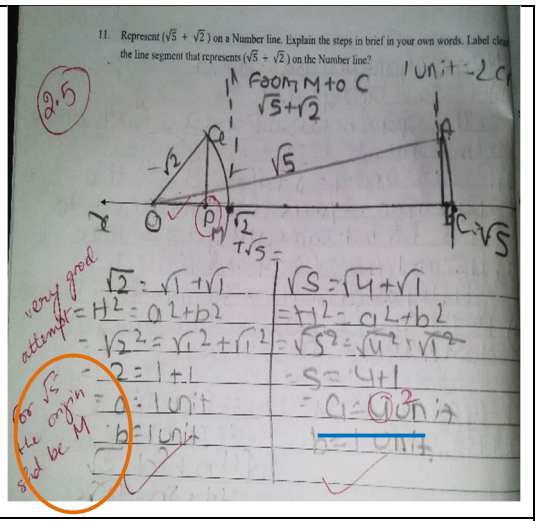
Q 9. Represent ($\sqrt{5} + \sqrt{2}$) on a Number line. Explain the steps in brief in your own words. Label clearly the line segment that represents ($\sqrt{5} + \sqrt{2}$) on the Number line?

**Table 23: Analysis of Posttest Question 9**

**(a) Scoring Rubric for Question 9**

| Scoring for Basic level | | Scoring for Higher level | |
|---|---|---|---|
| 2 | Correct and complete calculations and use of procedure to find a, b, a1, and b1 | 2 | Correct recognition of hidden meanings: using the values of a, b, a1 and b1 to represent $\sqrt{2}$ and $\sqrt{5}$ separately on a Number Line and organizing them correctly to represent $\sqrt{5} + \sqrt{2}$ on the Number Line |
| 1 | Partially correct /incomplete calculation and use of procedure to find a, b, a, a1 and b1 | 1 | Partially correct recognition of hidden meanings: using the values of a, b, a1 and b1 to represent $\sqrt{2}$ and $\sqrt{5}$ separately on a Number Line and organizing them correctly to represent $\sqrt{5} + \sqrt{2}$ on the No. Line |
| 0 | Incorrect or no computations/process | 0 | Incorrect or no recognition of hidden meaning and use of given information |

**(b) Sample of Student Response and Scoring for Question 9**

| | |
|---|---|
|  |  |
| **2 points** (Basic)for correct calculation and procedure to find a, b, a1, and b1.<br>**1 point** (Higher) for partial recognition of hidden meanings: using the values of a, b, a1 and b1 correctly to represent $\sqrt{2}$ and$\sqrt{5}$ on the Number Line but error in organizing them to represent $\sqrt{5}$ + $\sqrt{2}$ on the No. Line. | **1.5 point** (Basic) for correct calculation of a, b, and b1 but error in computing a1.<br>**1 point** (Higher) for correctly identification of different components ($\sqrt{2}$and $\sqrt{5}$ ) and representing $\sqrt{2}$ on the Number line, but error in representing $\sqrt{5}$. |

**(c) No. of Students who achieved Basic and Higher level competencies in Question 9**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 29 | 6.5 | 6.3 | 0 |
| **1** | 3.3 | 19.5 | 18.7 | 9.4 |
| **0** | 67.7 | 74 | 75 | 90.6 |

The above table indicates that with respect to ***Question 9 (Basic level)***,

29% of the students of the Experimental group did correct and complete computations; while 6.3% of the students of the Control group did correct and complete computations.

3.3% of students of the Experimental group did partially correct/incomplete computations; while 18.7% of the students of the Control group did partially correct/ incomplete computations.

67.7% of the students of the Experimental group did incorrect/no computations; while 75% of students of the Control group did incorrect/no computations.

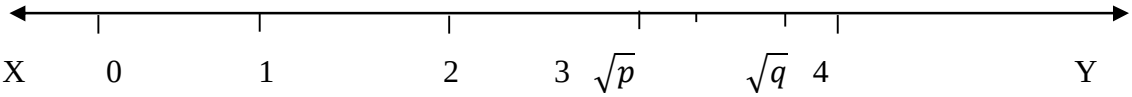
With respect to ***Question 9 (Higher level)***,

6.5% of the students of the Experimental group could recognize the hidden meaning and use the information correctly; while 0% of the students of the Control group could recognize the hidden meaning and use the information correctly.

19.5% of the students of the Experimental group could display the respective Higher level competency partially; while 9.4% of the students of the Control group could display the respective Higher level competency partially.

74% of the students of the Experimental group did not show the respective Higher level competency; while 90.6% of the students of the Control group did not show the respective Higher level competency.

**10. Analysis of Question 10 – Synthesis Level**




The figure above shows a Number Line XY, with Irrational numbers $\sqrt{p}$ and $\sqrt{q}$ lying on it. What should be the values of p and q? Choose the answer from the options given below. Give reasons for your answer. Also state why the other options are incorrect.

(a) p = 3.3, q = 3.4 (b) p = $3\frac{7}{9}$, q = $3\frac{8}{9}$

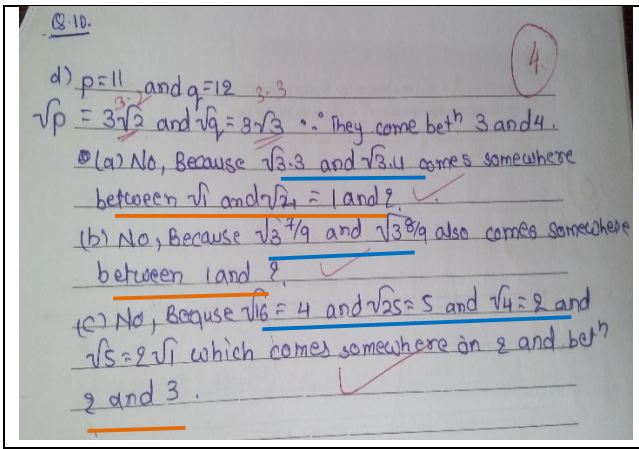
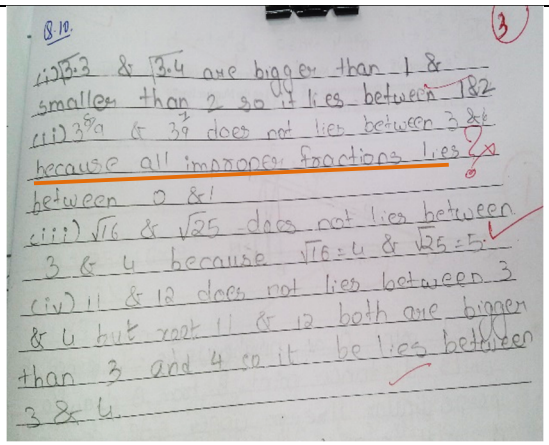
(c) p = $\sqrt{16}$, q = $\sqrt{25}$ (d) p = 11, q = 1

**Table 24: Analysis of Posttest Question 10**

**(a) Scoring Rubric for Question 10**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | Correct and complete computation of the values of the approximate values of $\sqrt{p}$ and $\sqrt{q}$ | 2 | Correctly using known concepts (approximate values of square roots) to create new ones (determining the positions of Irrational numbers with respect to Integers) and exact use of estimation skills |
| 1 | Partially correct/incomplete computation of the approximate values of $\sqrt{p}$ and $\sqrt{q}$ | 1 | Partially correct in using of known concepts to create new ones or error in estimation skills |
| 0 | Incorrect/ no computation | 0 | Incorrect or no use of known concepts to create new one and use of estimation skill |

**(b) Sample of Student Response and Scoring for Question 10**

| | |
|---|---|
|  |  |
| **2 points** (Basic) for correct computation of the approximate values of $\sqrt{p}$ and $\sqrt{q}$.<br>**2 points** (Higher) for correctly using known concepts (approximate values of square roots) to create new ones (determining the positions of Irrational numbers w.r.t Integers) & exact use of estimation skills. | **2 points** (Basic) for correct computation of the approximate values of $\sqrt{p}$ and $\sqrt{q}$.<br>**1 point** (Higher)for correctly using known concepts to create new ones and estimating positions of Irrational numbers in cases (i), (iii) and (iv) but incorrect in case (ii). |

**(c) No. of Students who achieved Basic and Higher level competencies in Q.10**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 15 | 12.2 | 3 | 0 |
| **1** | 36.5 | 21.2 | 9.2 | 9 |
| **0** | 48.5 | 66.6 | 87.8 | 91 |

The above table indicates that with respect to ***Question 10 (Basic level)***,

15% of the students in the Experimental group did correct and complete computations; while 3% of the students of the Control group did correct and complete computations.

36.5% of students of the Experimental group did partially correct/incomplete computations; while 9.2% of the students of the Control group did partially correct/incomplete computations.

48.5% of the students of the Experimental group did incorrect/no computations; while 87.8% of students of the Control group did incorrect/no computations.

With respect to **Question 10 (Higher level)**,

12.2% of the students of the Experimental group could use old ideas to create new ones and displayed estimation skills; while 0% of the students of the students of the Control group could use old ideas to create new ones and displayed estimation skills.

21.2% of the students of the Experimental group could display the respective Higher level competency partially; while 9% of the students of the Control group could display the respective Higher level competency partially.

66.6% of the students of the Experimental group did not show the respective Higher level competency; while 91% of the students of the Control group did not show the respective Higher level competency.

**11. Analysis of Question 11 – Synthesis Level**

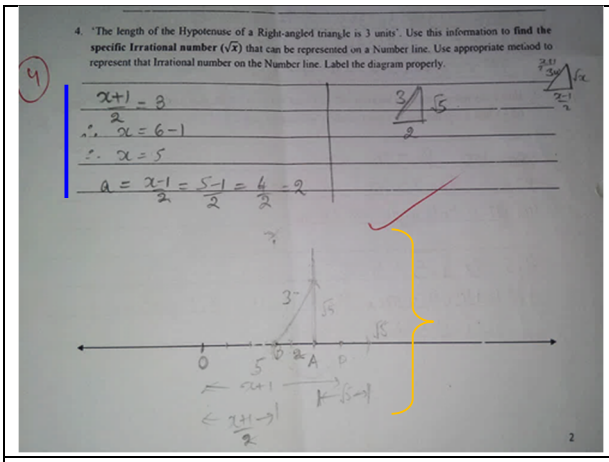
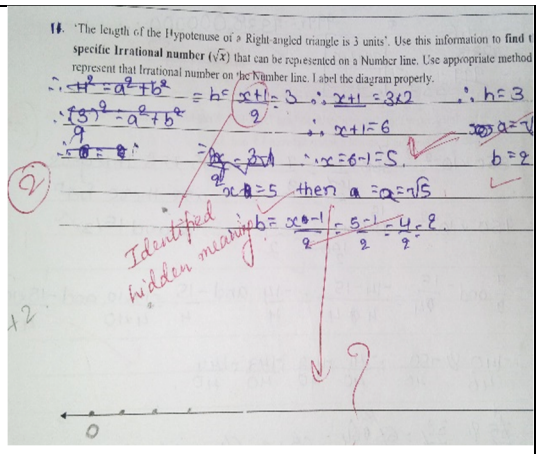
Q 11. 'The length of the Hypotenuse of a Right-angled triangle is 3 units'. Use this information to find the specific Irrational number $(\sqrt{x})$that can be represented on a Number line. Use appropriate method to represent that Irrational number on the Number line. Label the diagram properly.

**Table 25: Analysis of Posttest Question 11**

**(a) Scoring Rubric for Question 11**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | Correct and complete use of theory (Pythagoras theorem/Formula where perpendicular side of right angle triangle is $\sqrt{x}$ ) and computations to find the required values (sides a and b) | 2 | Correctly relate knowledge from several areas (Pythagoras theorem, square roots, construction of right angles, representing Irrational numbers on Number line) to form conclusions (identify correct procedure) |
| 1 | Partially correct use of the formula and computations to find required values | 1 | Partially correct in relating knowledge from several areas to form conclusions |
| 0 | Incorrect /no use of formula and computations to find required values | 0 | Incorrect /no skill of relating knowledge from several areas to form conclusions |

**(b) Sample of Student Response and Scoring for Question 11**

| | |
|---|---|
|  |  |
| **2 points** (Basic) for correct and complete use of theory (Pythagoras theorem/Formula where perpendicular side of right angle triangle is $\sqrt{x}$ ) and computations to find the required values (sides a, b).<br>**2 points** (Higher) for correctly relating knowledge from several areas (Pythagoras theorem, square roots, construction of right angles, representing Irrational numbers on No. line) to form conclusions. | **2 points** (Basic) for correctly computing the values of a and b using the formula used when perpendicular side is $\sqrt{x}$.<br>**0 point** (Higher) for not able to use the computed values for representing the Irrational number on the Number line. |

**(c) No. of Students who achieved Basic and Higher level competencies in Q.11**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 10 | 6.5 | 0 | 0 |
| **1** | 58 | 45 | 28 | 3 |
| **0** | 32 | 48.5 | 72 | 97 |

The above table indicates that with respect to ***Question 11 (Basic level)***,

10% of the students in the Experimental group correctly used the theory and did correct and complete computations to find values; while 0% of the students of the Control group correctly used the theory and did correct and complete computations to find values.

58% of students of the Experimental group were partially correct in the use of the theory and computations to find values; while 28% of the students of the Control group were partially correct in the use of the theory and computations to find values.

32% of the students of the Experimental group did not display the respective Basic level competency; while 72% of students of the Control group did not display the respective Basic level competency.

With respect to ***Question 11 (Higher level)***,

6.5% of the students of the Experimental group could use knowledge from several areas to form conclusions; while 0% of the students of the Control group could use knowledge from several areas to form conclusions.

45% of the students of the Experimental group could display the respective Higher level competency partially; while 3% of the students of the Control group could display the respective Higher level competency partially.

48.5% of the students of the Experimental group did not display the respective Higher level competency; while 97% of the students of the Control group did not display the respective Higher level competency.

**12. Analysis of Question 12 – Synthesis Level**

Q 12. Do as Directed :

(a) (i) Solve : 100 + 25 - 16 - 9 and find the square root of the solution

(ii) Solve : $\sqrt{100} + \sqrt{25} - \sqrt{16} - \sqrt{9}$

(b) (i) Solve : 100 ÷ 25 × 16 × 9 and find the square root of the solution

(ii) Solve : $\sqrt{100} \div \sqrt{25} \times \sqrt{16} \times \sqrt{9}$

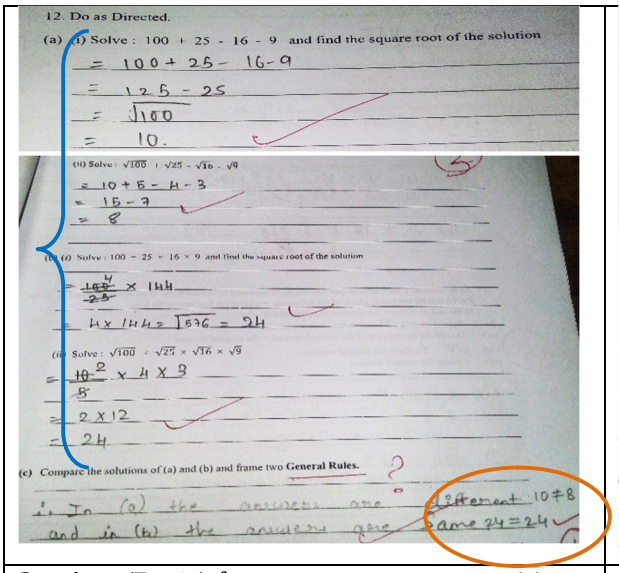
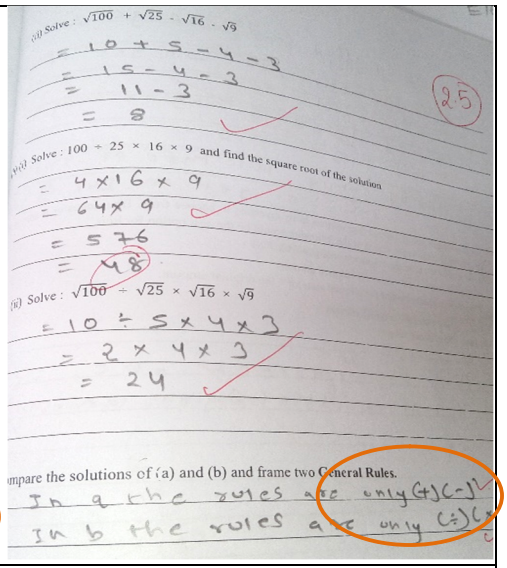
(c) Compare the solutions of (a) and (b) and frame two **General Rules.**

**Table 26: Analysis of Posttest Question 12**

**(a) Scoring Rubric for Question 12**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | Correct and complete computations (a) &(b) | 2 | Correct generalizing from (a) and (b) |
| 1 | Partially correct/incomplete computations (a)& (b) | 1 | Partially correct in generalizing from (a) &(b) |
| 0 | Incorrect /no computations | 0 | Incorrect /no generalization |

**(b) Sample of Student Response and Scoring for Question 12**

| | |
|---|---|
|  |  |
| **2 points** (Basic) for correct computations (a) (b).<br>**1 point** (Higher) for seeing the correct pattern but not able to write it in a generalized mathematical form. | **2 points** (Basic) for correct computations (a) and (b).<br>**0.5 point** (Higher) for seeing the partially correct pattern. |

**(c) No. of Students who achieved Basic and Higher level competencies in Q.12**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 53 | 3 | 21.8 | 0 |
| **1** | 31.3 | 31.3 | 37.6 | 6.3 |
| **0** | 15.7 | 65.7 | 40.6 | 93.7 |

The above table indicates that with respect to ***Question 12 (Basic level)***,

53% of the students in the Experimental group did correct and complete computations in all three cases (a), (b) and (c); while 21.8% of the students of the Control group did correct and complete computations in all three cases (a), (b) and (c).

31.3% of students of the Experimental group did partially correct/incomplete computations; while 37.6% of the students of the Control group did partially correct/incomplete computations.

15.7% of the students of the Experimental group did not display the respective Basic level competency; while 40.6% of students of the Control group did not display the respective Basic level competency.

With respect to ***Question 12 (Higher level)***,

3% of the students of the Experimental group could see the general pattern and frame general rules; while 0% of the students of the Control group could see the general pattern and frame general rules.

31.3% of the students of the Experimental group displayed the respective Higher level competency partially; while 6.3% of the students of the Control group displayed the respective Higher level competency partially.

65.7% of the students of the Experimental group did not display the respective Higher level competency; while 93.7% of the students of the Control group did not display the respective Higher level competency.

**13. Analysis of Question 13 – Evaluation Level**

Q 13. A student was given a task to construct problems of the following type as per the given conditions. Mention in each case what kind of number should he take as 'x' and 'y'. Give one example in each case to substantiate your answer.

(i) x + y ; such that the sum is surely an Irrational number (one example)

(ii) x - y ; such that the difference is surely a Rational number (one example)

(iii) x × y; such that the product may be Rational or an Irrational number (two examples)

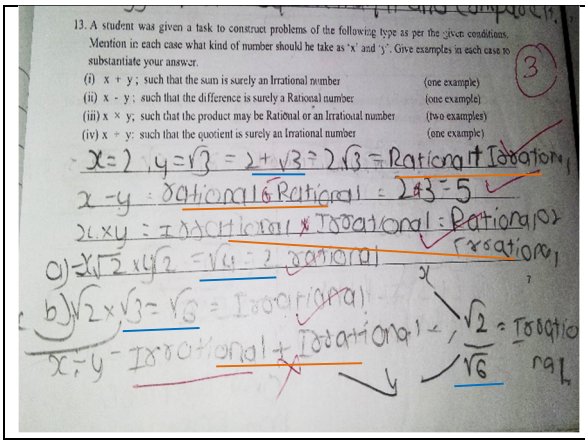
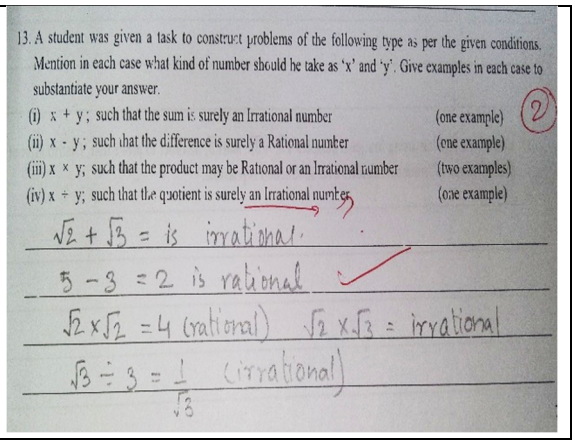
(iv) x ÷ y; such that the quotient is surely an Irrational number (one example)

**Table 27: Analysis of Posttest Question 13**

**(a) Scoring Rubric for Question 13**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | Correct examples given in all the cases and correct computations done | 2 | Different properties of operations on Rational and Irrational numbers are compared and contrasted to infer the values of x and y: correctly for all the cases |
| 1 | Correct examples given in half of the cases and partially correct computations done | 1 | Different properties of operations on Rational and Irrational numbers are compared and contrasted to infer the values of x and y: correctly for half of the cases |
| 0 | No examples given and no computations done | 0 | Compare and discriminate between ideas to infer values : incorrect or not done |

**(b) Sample of Student Response and Scoring for Question 13**

| | |
|---|---|
|  |  |
| **1.5 points** (Basic) for giving correct examples in cases (i), (ii) and (iii), incorrect in (iv) based on the choices made (Rational/Irrational), partial errors in computations.<br>**1.5 points** (Higher) for correctly comparing the properties related to the operations on Real numbers and inferring the values of x and y in the cases (i), (ii) and (iii) but not in case (iv). | **2 points** (Basic) for giving correct examples in cases (i), (ii), (iii) (iv) based on the choices made.<br>**0 point** (Higher) for not using the properties related to operations on Real numbers to infer the values of x and y in each case. |

**(c) No. of Students who achieved Basic and Higher level competencies in Question 13**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 22.6 | 9.7 | 3.1 | 0 |
| **1** | 35.4 | 25.8 | 12.5 | 9.4 |
| **0** | 42 | 64.5 | 84.4 | 90.6 |

The above table indicates that with respect to ***Question 13 (Basic level)***,

22.6% of the students of the Experimental group provided correct examples in all the cases and did correct computations; while 3.1% of the students of the Control group provided correct examples in all the cases and did correct computations.

35.4% of students of the Experimental group provided examples for half of the cases or did partially correct computations; while 12.5% of the students of the Control group provided examples for half of the cases or did partially correct computations.

42% of the students of the Experimental group did not display the respective Basic level competency; while 84.4% of the students of the Control group did not display the respective Basic level competency.

With respect to ***Question 13 (Higher level)***,

9.7% of the students of the Experimental group could compare and discriminate between ideas and infer the values; while 0% of the students of the Control group could compare and discriminate between ideas and infer the values.

25.8% of the students of the Experimental group displayed the respective Higher level competency partially; while 9.4% of the students of the Control group displayed the respective Higher level competency partially.

64.5% of the students of the Experimental group did not display the respective Higher level competency; while and 90.6% of the students of the Control group did not display the respective Higher level competency.

**14. Analysis of Question 14 – Evaluation**

Q 14. An investment policy offered four options to its investors to choose from. If an investor wants to invest Rs. 10,000 for ten years, which of the following would be the best option for him. "At the end of the term the investor would get back

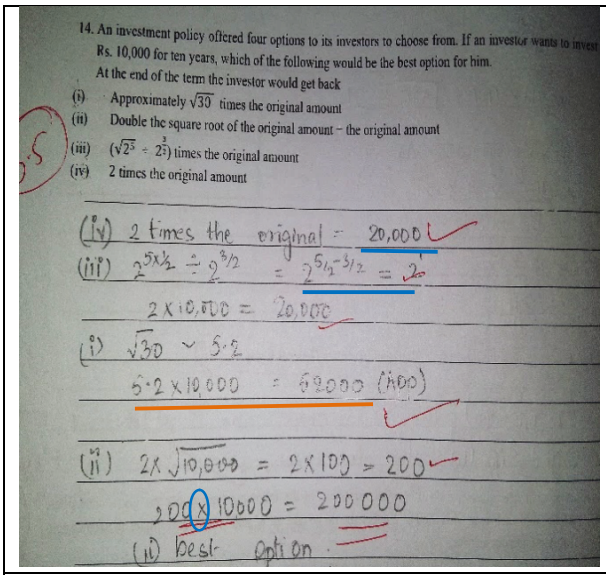
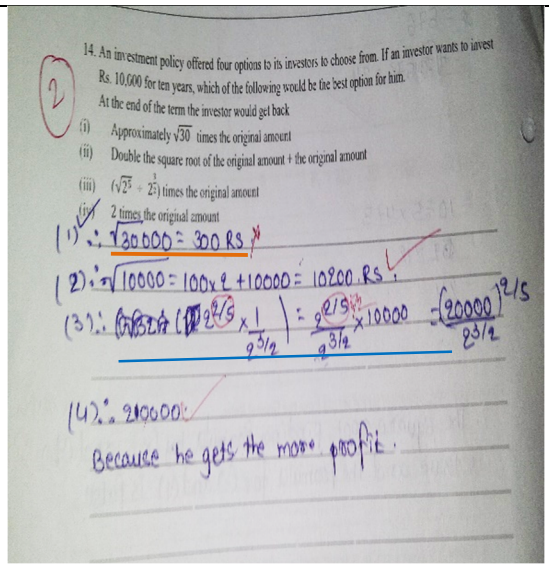
(i) Approximately $\sqrt{30}$ times the original amount (ii) Double the square root of the original amount + the original amount (iii)$(\sqrt{2^5} \div 2^{\frac{3}{2}})$ times the original amount (iv) 2 times the original amount"

**Table 28: Analysis of Posttest Question 14**

**(a) Scoring Rubric for Question 14**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | Correct and complete computations for cases (ii), (iii) and (iv) | 2 | Correct approximation in case (i) and Making choices based on reasoned arguments: correct in all four cases |
| 1 | Partially correct/incomplete computations in cases (ii), (iii) and (iv) | 1 | Partially correct approximation in case (i) and Making choices based on reasoned arguments: correct in half cases |
| 0 | Incorrect or no computations | 0 | Incorrect approximation in case (i) and Making choices based on reasoned arguments: incorrect/ not done in all |

**(b) Sample of Student Response and Scoring for Question 14**

| | |
|---|---|
|  |  |
| **1.5 points** (Basic) for correct &complete computations for (iii), (iv), minor error in (ii).<br>**2 points** (Higher) for correct approximation in case (i) and making choices based on reasoned arguments: done correctly in all the cases. | 1 point (Basic) for correct computations in cases (ii) and (iv) and error in (iii).<br>1 point (Higher) for incorrect approximation in case (i) butcorrect choices made based on reasoned arguments in half of the cases. |

**(c) No. of Students who achieved Basic and Higher level competencies in Q.14**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 15.6 | 6.4 | 3 | 3 |
| **1** | 31.3 | 22.6 | 6 | 0 |
| **0** | 53.1 | 71 | 91 | 97 |

The above table indicates that, with respect to ***Question 14 (Basic level)***,

15.6% of the students of the Experimental group did correct and complete computations; while 3% of the students of the Control group did correct and complete computations.

31.3% of students of the Experimental group did incomplete/partially correct computations; while 6% of the students of the Control group did incomplete/partially correct computations.

53.1% of the students of the Experimental group did not display the respective Basic level competency; while 91% of the students of the Control group did not display the respective Basic level competency.

With respect to ***Question 14 (Higher level)***,

6.4% of the students of the Experimental group made choices based on reasoned arguments correctly for all four cases; while 3% of the students of the Control group made choices based on reasoned arguments correctly for all four cases.

22.6% of the students of the Experimental group made choices based on reasoned arguments correctly in half of the cases, and thus could partially display the respective Higher level competency; while 0% of the students of the Control group made choices based on reasoned arguments correctly in half of the cases, and thus could partially display the respective Higher level competency.

71% of the students of the Experimental group did not display the respective Higher level competency; while 97% of the students of the Control group did not display the respective Higher level competency.

**15. Analysis of Question 15 – Evaluation**

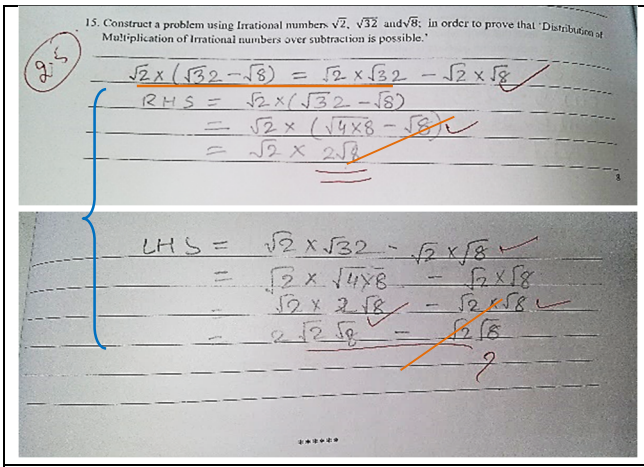
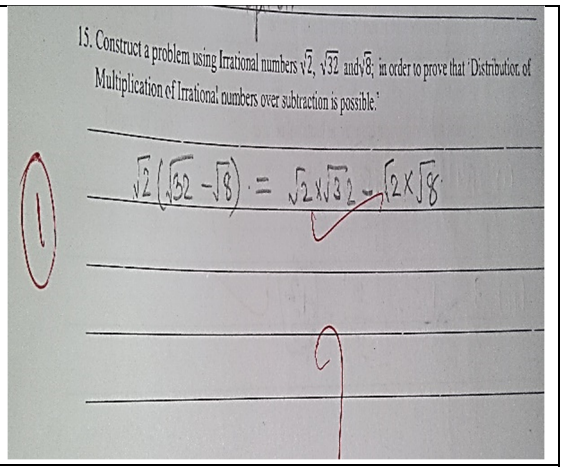
Q 15. Construct a problem using Irrational numbers $\sqrt{2}$, $\sqrt{32}$ and$\sqrt{8}$; in order to prove that 'Distribution of Multiplication of Irrational numbers over subtraction is possible.'

**Table 29: Analysis of Posttest Question 15**

**(a) Scoring Rubric for Question 15**

| **Scoring for Basic level** | | **Scoring for Higher level** | |
|---|---|---|---|
| 2 | All computations involved throughout the solution is correct | 2 | Construction of problem done correctly and theory (property) correctly verified |
| 1 | Partially correct computations done | 1 | Construction of problem correctly done but verification of LHS and RHS incorrect or vice versa |
| 0 | Incorrect or no computations | 0 | Incorrect or no construction and verification |

**(b) Sample of Student Response and Scoring for Question 15**

| | |
|---|---|
|  |  |
| **1 point** (Basic) for error made in computation, but procedure followed correctly.<br>**1.5 points** (Higher) for construction of problem done correctly and (property) verified with minor error. | **0 point** (Basic) for no computations.<br>**1 point** (Higher) for correctly constructing the problem. |

**(c) No. of Students who achieved Basic and Higher level competencies in Q.15**

| Score Point | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Basic Level (%) | Higher Level (%) | Basic Level (%) | Higher Level (%) |
| **2** | 9.7 | 6.5 | 0 | 0 |
| **1** | 29 | 19.4 | 9.1 | 0 |
| **0** | 61.3 | 74.1 | 90.9 | 100 |

The above table indicates that with respect to ***Question 15 (Basic level)***,

9.7% of the students of the Experimental group did all the computations involved throughout the solution correctly; while 0% of the students of the Control group did all the computations involved throughout the solution correctly.

29% of students of the Experimental group did partially correct computations; while 9.1% of the students in Control group did partially correct computations.

61.3% of the students of the Experimental group did not display the respective Basic level competency; while 90.9% of students of the Control group did not display the respective Basic level competency.

With respect to ***Question 15 (Higher level)***,

6.5% of the students of the Experimental group constructed the problem and verified the property correctly; while 0% of the students of the Control group constructed the problem and verified the property correctly.

19.4% of the students of the Experimental group constructed the problem correctly but made error or could not verify the property or vice versa, and thus partially displayed the

respective Higher level competency; while 0% of the students of the Control group constructed the problem correctly but made error or could not verify the property or vice versa, and thus partially displayed the respective Higher level competency.

74.1% of the students of the Experimental group did not display the respective Higher level competency; while 100% of the students of the Control group did not display the respective Higher level competency.

The question-wise analysis individually recorded in the above section is tabulated comprehensively in the Table 30 (Higher level competencies) and Table 31 (Basic level competencies) in the following section. Graphical representations of the same are shown in Figures 2, 3 and 4.

**Table 30: Comparison of the Experimental and Control group students based on acquisition of Higher Level Competencies in Posttest**

| Level | Q | Higher level competencies with respect to the content – Real Numbers | Experimental | | Control | |
|---|---|---|---|---|---|---|
| | | | No. of students (%) | Aver-age (%) | No. of students (%) | Aver-age (%) |
| Comprehension | 1 | Grasping of the holistic meaning and justifying it with evidence | C - 42.4<br>P - 42.4 | C-27.5<br>P-37.3 | C - 6.2<br>P - 62.5 | C-5.1<br>P-32.4 |
| | 2 | Using mathematical rules and ordering, grouping and differentiating components | C – 28<br>P – 18 | | C - 6.2<br>P - 12.6 | |
| | 3 | Understanding of given information, interpretation of facts after comparing & contrasting and justifying it with mathematical reasoning | C – 12<br>P - 51.5 | | C - 3<br>P - 22 | |
| Application | 4 | Using the information to solve the new problem | C - 12.5<br>P - 24.5 | C-13.7<br>P-33.6 | C - 3<br>P - 12.2 | C – 1<br>P-14.7 |
| | 5 | Using concepts/theory in a new situation | C – 13<br>P – 45 | | C - 0<br>P - 28.2 | |
| | 6 | Using information to solve the problem in a new context | C - 15.6<br>P - 31.3 | | C - 0<br>P - 6.3 | |
| Analysis | 7 | Recognition of hidden meanings and seeing the pattern | C - 16.2<br>P – 29 | C - 9.7<br>P-20.5 | C - 3.1<br>P - 18.8 | C – 1<br>P - 9.4 |
| | 8 | Identification of different components and organizing them appropriately to infer value | C - 6.5<br>P - 12.9 | | C - 0<br>P - 0 | |
| | 9 | Recognizing the hidden meaning, identifying the different components and organizing them appropriately to infer value | C - 6.5<br>P - 19.5 | | C - 0<br>P - 9.4 | |
| Synthesis | 10 | Using old ideas to create new ones and use of estimation skills | C - 12.2<br>P - 21.2 | C - 7.2<br>P-32.5 | C - 0<br>P - 9 | C – 0<br>P - 6.1 |
| | 11 | Relating knowledge from several areas to form conclusions | C - 6.5<br>P – 45 | | C - 0<br>P - 3 | |
| | 12 | Seeing the pattern and framing general rule | C – 3<br>P - 31.3 | | C - 0<br>P - 6.3 | |
| Evaluation | 13 | Comparing and discriminating between general ideas to infer the values with justification | C - 9.7<br>P - 25.8 | C - 7.5<br>P-22.6 | C - 0<br>P - 9.4 | C – 1<br>P - 3.1 |
| | 14 | Making choices based on reasoned arguments | C - 6.4<br>P - 22.6 | | C - 3<br>P - 0 | |
| | 15 | Verifying value with evidence | C - 6.5<br>P - 19.4 | | C - 0<br>P - 0 | |

C – Completely P - Partially

### 5.2.1.2 Interpretation of the Posttest responses for Higher level competencies

The above Table 30 indicates that on an average 27.5% of students of the Experimental group and 5.1% of the Control group have 'completely' achieved; and 37.3% and 32.4% of the Experimental and the Control group respectively have 'partially' achieved Higher level competencies like: *Grasping of the holistic meaning; Using mathematical rules and ordering, grouping and differentiating components; Interpretation of facts after comparing & contrasting; and Justifying with mathematical reasoning* - for Comprehension level questions of the content 'Real Numbers'.

On an average 9.7% of students of the Experimental group and 1% of the Control group have 'completely' achieved; and 33.6% and 14.7% of the Experimental and the Control group respectively have 'partially' achieved Higher level competencies like: *Using information /concepts/theories/ in new situation/different context to solve problems* – for Application level questions of the content 'Real Numbers'.

On an average 13.7% of students of the Experimental group and 1% of the Control group have 'completely' achieved; and 20.5% and 9.4% of the Experimental and the Control group respectively have 'partially' achieved Higher level competencies like: *Recognition of hidden meanings and seeing the pattern; Identification of different components and organizing them appropriately to infer value*– for Analysis level questions of the content 'Real Numbers'.

On an average 7.2% of students of the Experimental group and 0% of the Control group have 'completely' achieved; and 32.5% and 6.1% of the Experimental and the Control group respectively have 'partially' achieved Higher level competencies like: *Using old ideas to create new ones; Use of estimation skills; Relating knowledge from several areas to form conclusions; Seeing the pattern and framing general rule* – for Synthesis level questions of the content 'Real Numbers'.

On an average 7.5% of students of the Experimental group and 1% of the Control group have 'completely' achieved and 22.6% and 3.1% of the Experimental and the Control group respectively have 'partially' achieved Higher level competencies like: *Comparing and discriminating between general ideas to infer the values with justification; Making choices based on reasoned arguments; Verifying value with evidence* – for Evaluation level questions of the content 'Real Numbers'. The graph below visually displays the above statements.

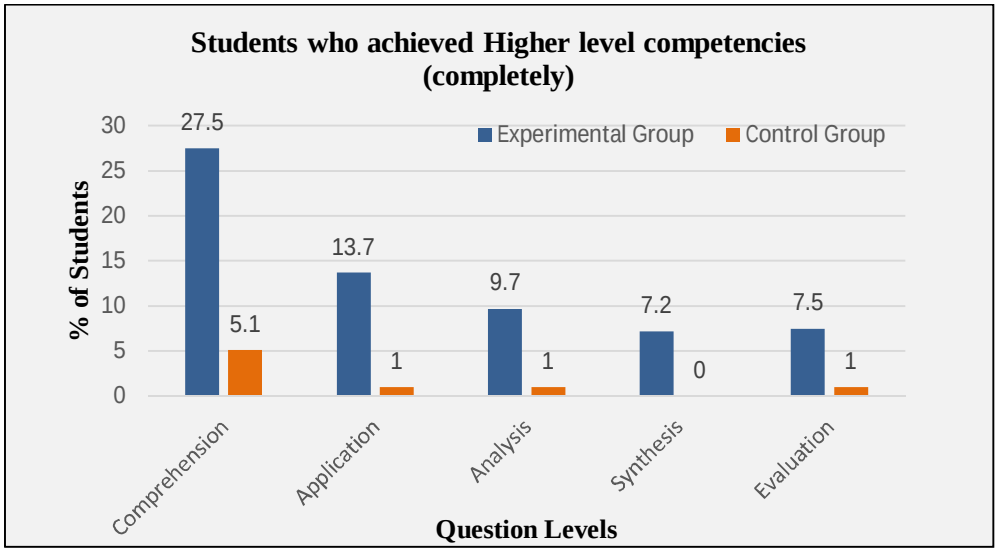



**Figure 1:** Comparative Graph of % of students of Experimental and Control group who have completely achieved Higher level competencies in different Question levels

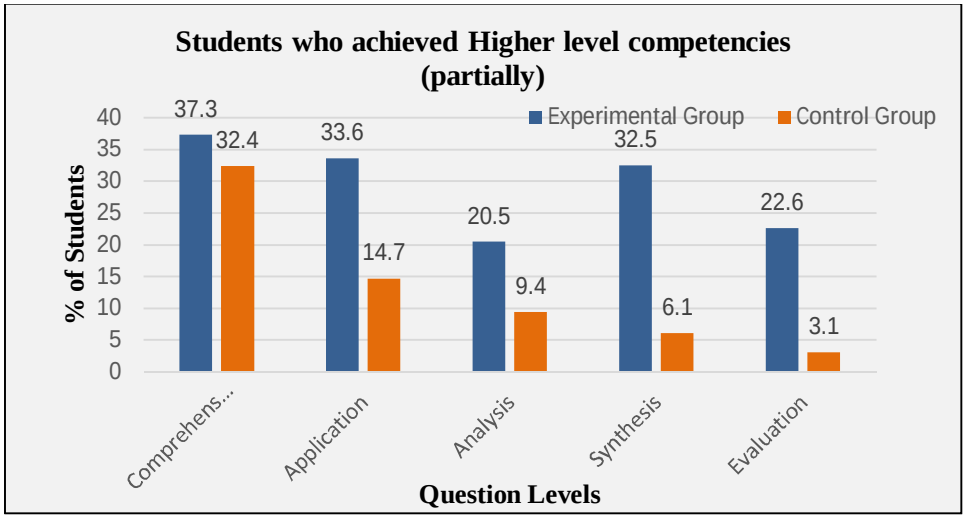



**Figure 2**: Comparative Graph of % of students of Experimental and Control group who have partially achieved Higher level competencies in different Question levels

**Table 31: Comparison of the Experimental and Control group students based on acquisition of Basic Level Competencies in Posttest (HOTS questions)**

| Q No. | Basic Level completely achieved | | | | |
|---|---|---|---|---|---|
| | % of Students | | Level-wise (average % of students) | | |
| | Experimental | Control | Levels of Question | Experimental | Control |
| 1 | 78.8 | 46.8 | Comprehension | **49.5** | **25** |
| 2 | 45.5 | 22 | | | |
| 3 | 24.3 | 6.2 | | | |
| 4 | 46 | 12.5 | Application | **38.6** | **9.3** |
| 5 | 29.2 | 12.5 | | | |
| 6 | 40.6 | 3 | | | |
| 7 | 25.8 | 9.4 | Analysis | **24.7** | **5.2** |
| 8 | 19.4 | 0 | | | |
| 9 | 29 | 6.3 | | | |
| 10 | 15 | 3 | Synthesis | **26** | **8.3** |
| 11 | 10 | 0 | | | |
| 12 | 53 | 21.8 | | | |
| 13 | 22.6 | 3.1 | Evaluation | **16** | **2** |
| 14 | 15.6 | 3 | | | |
| 15 | 9.7 | 0 | | | |

The above Table 31 indicates that on an average 49.5% of students of the Experimental group and 25% of students of the Control group have 'completely' achieved the Basic level competencies like: *Computations of mathematical and exponential operations; Using algorithmic procedures; Identification of basic rules/properties/concepts* for the Comprehension level questions of the content 'Real Number'.

On an average, 38.6% of students of the Experimental group and 9.3% of the Control group have achieved the Basic level competencies for the Application level questions of the content 'Real Number'.

On an average, 24.7% of students of the Experimental group and 9.2% of the Control group have achieved the Basic level competencies for the Analysis level questions of the content 'Real Number'.

On an average, 26% of students of the Experimental group and 8.3% of the Control group have achieved the Basic level competencies for the Synthesis level questions of the content 'Real Number'.

On an average, 16% of students of the Experimental group and 2% of the Control group have achieved the Basic level competencies for the Evaluation level questions of the content 'Real Number'.

The above statements are displayed by the graph shown below.

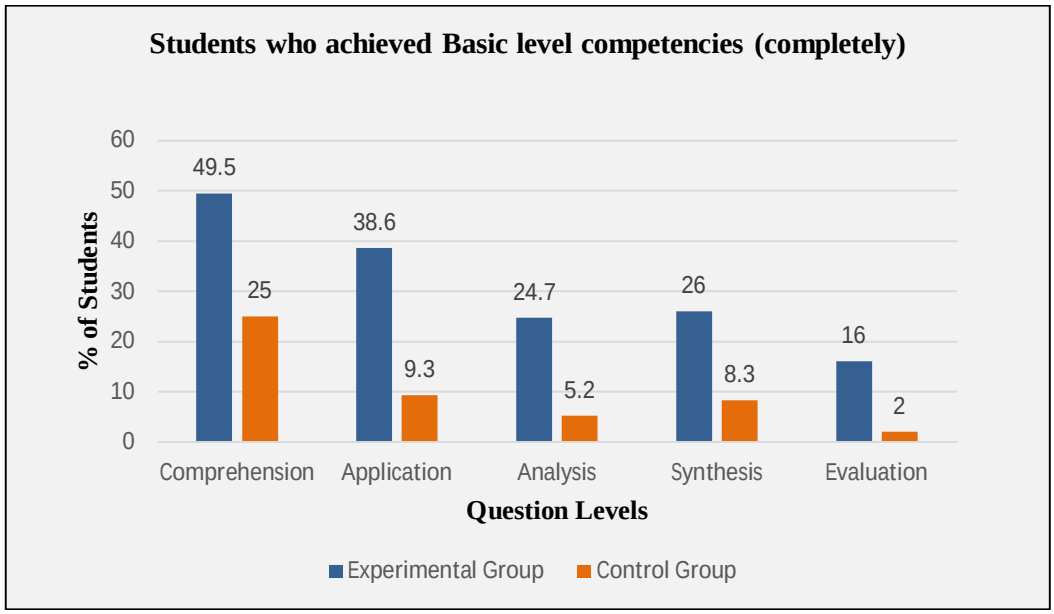



**Figure 3:** Comparative Graph of % of students of Experimental and Control group who have 'completely' achieved Basic level competency in different Question levels

### 5.2.2 Analysis and interpretation of Posttest responses for achievement (sub-objectives 3.3 and 3.4)

The relative effectiveness of the developed Instructional Package over the Conventional method of teaching was checked using the mean Achievement scores of the Posttest. Thus the hypotheses that were to be checked were:

Hypothesis 1- $H_0$: There is no significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional package over the ones exposed to the Conventional method of teaching for HOTS questions at the Comprehension level in the content 'Real Numbers'.

Hypothesis 2- $H_0$: There is no significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional package over the ones exposed to the Conventional method of teaching for HOTS questions at the Application level in the content 'Real Numbers'.

Hypothesis 3- $H_0$: There is no significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional package over the ones exposed to the Conventional method of teaching for HOTS questions at the Analysis level in the content 'Real Numbers'.

Hypothesis 4- $H_0$: There is no significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional package over the ones exposed to the

Conventional method of teaching for HOTS questions at the Synthesis level in the content 'Real Numbers'.

Hypothesis 5- $H_0$: There is no significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional package over the ones exposed to the Conventional method of teaching for HOTS questions at the Evaluation level in the content 'Real Numbers'.

Hypothesis 6- $H_0$: There is no significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional package over the ones exposed to the Conventional method of teaching for HOTS questions at the Evaluation level in the content 'Real Numbers'.

#### 5.2.2.1 Analysis and interpretation of achievement scores with respect to the cognitive levels

The independent t-test was used to check whether the difference between the Mean Achievement scores of Posttest of the Experimental group and Control group was significant with respect to Cognitive Levels- Comprehension, Application, Analysis, Synthesis and Evaluation. The same is presented in Table 32 below.

**Table 32: Difference between the Mean Achievement Scores of Posttest of the Control group and Experimental group with respect to Cognitive Levels**

| Cognitive Level | Group | N | Mean | SD | df | t | Sig. (p-value) | Remarks |
|---|---|---|---|---|---|---|---|---|
| Comprehension | Experimental | 33 | 5.85 | 3.22 | 32 | 3.68 | 0.00 | S |
| | Control | 32 | 3.22 | 2.47 | 31 | | | |
| Application | Experimental | 33 | 3.88 | 2.72 | 32 | 3.56 | 0.00 | S |
| | Control | 32 | 1.78 | 1.94 | 31 | | | |
| Analysis | Experimental | 33 | 1.97 | 1.83 | 32 | 3.18 | 0.00 | S |
| | Control | 32 | 0.81 | 0.97 | 31 | | | |
| Synthesis | Experimental | 33 | 2.73 | 2.45 | 32 | 3.80 | 0.00 | S |
| | Control | 32 | 0.98 | 0.86 | 31 | | | |
| Evaluation | Experimental | 33 | 1.50 | 1.86 | 32 | 3.00 | 0.00 | S |
| | Control | 32 | 0.38 | 0.98 | 31 | | | |

The above table shows that:

For the Cognitive level – Comprehension, the obtained 't' value 3.68 is greater than the table value 2.04 at 0.05 level ($p<0.05$). Hence, the Null Hypothesis 1 is rejected.

For the Cognitive Level – Application, the obtained ‘t’ value 3.56 is greater than the table value 2.04 at 0.05 level ($p<0.05$). Hence, the Null Hypothesis 2 is rejected.

For the Cognitive Level – Analysis, the obtained ‘t’ value 3.18 is greater than the table value 2.04 at 0.05 level ($p<0.05$). Hence, the Null Hypothesis 3 is rejected.

For the Cognitive Level – Synthesis, the obtained ‘t’ value 3.80 is greater than the table value 2.04 at 0.05 level ($p<0.05$). Hence, the Null Hypothesis 4 is rejected.

For the Cognitive Level – Evaluation, the obtained ‘t’ value 3.00 is greater than the table value 2.04 at 0.05 level ($p<0.05$). Hence, the Null Hypothesis 5 is rejected.

So, there is a significant difference between the Experimental group and the Control group students in their Mean Achievement scores on Posttest with respect to the Cognitive Levels – Understanding, Application, Analysis, Synthesis and Evaluation.

#### 5.2.2.2 Analysis and interpretation based on overall achievement scores

The independent t-test was used to check whether the difference between Mean Achievement scores of the Experimental and the Control group on Posttest is significant or not. The same is presented in Table 33.

**Table 33: Significance of difference between Mean Achievement scores of the Experimental and the Control group on Posttest**

| Group | N | M | SD | df | t | Sig.(p value) | Remarks |
|---|---|---|---|---|---|---|---|
| Experimental | 33 | 15.97 | 9.47 | 32 | 4.53 | 0.00003 | S |
| Control | 32 | 7.17 | 5.98 | 31 | | | |

The independent sample t-test shown in above table indicates that the obtained ‘t’ value 4.53 is greater than that of the table value 2.04 at 0.05 level ($p<0.05$). Hence, the Null Hypothesis 6 is rejected.

Also, the Mean Achievement scores of the Experimental group on Posttest (M=15.74) is greater than the Mean Achievement scores of the Control group on Posttest (M=7.17).

So, there is a significant difference between the Experimental group and the Control group students in their Mean Achievement scores on the HOTS questions included in the Posttest at all levels in the content ‘Real Numbers’.

## 5.3 Description of Analysis and Interpretation of Reaction Scale in Stage II

The Objective 4 of the present Study is – “To study the reaction of students on the developed Instructional Package and its implementation.”

A five-point Reaction scale [Appendix A (7)] was designed by the investigator and given to the samples of the Experimental group after the implementation of the entire

intervention. The Scale offered opportunities to students to give their feedback on the method of teaching; learning materials; assessment materials; concept clarity on the topic Real numbers; ability to generalize, verify, estimate; and attitude towards the subject of Mathematics as a whole. The Reaction scale contained 25 statements based on Likert scale ranging from 'strongly agree' to 'strongly disagree'. Out of the 25 statements 20 statements were of positive polarity and 5 statements were of negative polarity. Positive polarity statements are given points as follows:

**Points for Positive Polarity Statements**

| **Response** | Strongly Agree (SA) | Agree (A) | Not Decided (NA) | Disagree (DA) | Strongly Disagree (SD) |
|---|---|---|---|---|---|
| **Points** | 5 | 4 | 3 | 2 | 1 |

Statements 1, 2, 3, 4, 5, 6, 7, 8,9, 10, 11, 13, 14, 15, 17, 18, 19, 22, 23 and 25 of the Reaction scale were of positive polarity.

**Points for Negative polarity Statements**

| **Response** | Strongly Agree (SA) | Agree (A) | Not Decided (NA) | Disagree (DA) | Strongly Disagree (SD) |
|---|---|---|---|---|---|
| **Points** | 1 | 2 | 3 | 4 | 5 |

Statements 12, 16, 20, 21 and 24 of the Reaction scale were of negative polarity.

Frequency and Intensity Index for each statement was used as data analysis technique. The Intensity Index for positive polarity statements was calculated using:

$$\text{Intensity Index} = \frac{\sum_{i=1}^{5} fi.xi}{n}$$

$f_i$ = frequency of responses

$x_i$ = points (1, 2, 3, 4, 5)

n = Total number of samples = 31

The Intensity Index for negative polarity statements was calculated using:

$$\text{Intensity Index} = \frac{\sum_{i=5}^{1} fi.xi}{n}$$

$f_i$ = frequency of responses

$x_i$ = points (5, 4, 3, 2, 1)

n = Total number of samples = 31

The Reaction scale was designed by the investigator to get students' reaction on the following aspects:

1. Students' reaction on the Instructional strategies implemented in the classroom.

Statements 1, 2, 3, 4, 5 and 6 were constructed for this purpose.

2. Students' reaction on their understanding on different concepts and processes of the unit 'Real Numbers'.

Statements 7, 8, 9, 10 and 11 were constructed for this purpose.

3. Students' reaction on their feelings/perceptions towards the unit 'Real numbers' and towards the subject of Mathematics as a whole.

Statements 12, 13, 14, 15 and 16 were constructed for this purpose.

4. Students' reaction on the Worksheets solved during the intervention period.

Statements 17, 18, 19, 20 and 21 were constructed for this purpose.

5. Students' reaction on the Formative assessments - Evaluation1 and Evaluation 2.

Statements 22, 23 and 24 were constructed for this purpose.

6. Student's reaction on the overall Instructional Package and its implementation.

Statement 25 was constructed for this purpose.

Analyzed data for each of the above aspects is presented as below.

The responses of the students on the targeted statements were respectively counted for the categories SA, A, ND, DA and SD; which were then multiplied by respective scores as per the categories; each of the total scores (per category) were then added up; which was then divided by the numbers of students. This was how the Intensity Index for each statement was calculated.

### 5.3.1 Analysis and interpretation of students' reaction on the instructional strategies implemented in the classroom

Tabulated below are the statements that allow students to reflect on the Instructional strategies used in the classroom during the implementation of the Instructional Package. The number of students who Strongly agreed, Agreed, Not Decided, Disagreed, and Strongly Disagreed for respective statements and Intensity Index for each is computed in Table 36.

**Table 34: Students' reaction on the Instructional strategies implemented in the classroom**

| No | Statements | SA | A | ND | DA | SD | II |
|---|---|---|---|---|---|---|---|
| **1** | The previous knowledge discussed before the beginning of a new topic helped me to understand the topic better. | 15 | 16 | 0 | 0 | 0 | **4.48** |
| **2** | The detailed in-depth explanation of each concept helped in better understanding. | 14 | 17 | 0 | 0 | 0 | **4.45** |
| **3** | The examples, counter-examples, contrasts, similarities used to explain concepts made my understanding better. | 6 | 17 | 8 | 0 | 0 | **3.94** |
| **4** | The sequencing of the sub-topics which was different than that given in textbook, helped in better understanding. | 12 | 13 | 6 | 0 | 0 | **4.19** |
| **5** | The questions put forward by the teacher during her instructions forced me think further than the usual. | 9 | 12 | 9 | 1 | 0 | **3.94** |
| **6** | The time given for each sub-topic was sufficient to bring about proper understanding regarding the concept. | 16 | 15 | 0 | 0 | 0 | **4.52** |
| | | | | | | **Average** | **4.25 (85%)** |

From the above Table 36, it can be observed that the average Intensity Index is 4.25, which is very near to the highest score 5; for the statements related to the Instructional strategies used in the classroom that caused better understanding of the content 'Real numbers' in students. It shows that 85% of students have responded that the different strategies like discussion of previous knowledge with reference to each sub-topic; detailed in-depth explanation of each concept; use of examples, counter-examples, contrasts, similarities in explanations; use of questioning technique to promote thinking; resequencing the topics for better links and holistic understanding; and enough time given for each sub-topic helped the students to understand the topic 'Real numbers' better than the usual form of teaching.

### 5.3.2 Analysis and interpretation of students' reaction on their understanding on different concepts and processes of the unit 'Real Numbers'

Tabulated below are the statements that allow students to reflect on their understanding of the concepts of Real Numbers taught using the Instructional Package. The number of

students who Strongly agreed, Agreed, Not Decided, Disagreed, and Strongly Disagreed for respective statements and Intensity Index for each is computed below.

**Table 35: Students' reaction on their understanding on different concepts and processes of the unit 'Real Numbers'**

| No. | Statements | SA | A | ND | DA | SD | II |
|---|---|---|---|---|---|---|---|
| **7** | I have understood all the concepts related to the topic 'Real numbers' very clearly. | 15 | 15 | 0 | 1 | 0 | **4.42** |
| **8** | I have understood the holistic meaning and structure of the Numbering system – Real number | 9 | 18 | 4 | 0 | 0 | **4.16** |
| **9** | I have understood the inter-connections between the sub-topics within Real numbers completely. | 6 | 22 | 3 | 0 | 0 | **4.10** |
| **10** | I got better understanding about some basic mathematical facts which were not clear to me earlier. | 13 | 9 | 3 | 6 | 0 | **3.94** |
| **11** | I have understood complex aspects of Mathematics like estimation, proofs, verification, and generalization with reference to Real numbers | 7 | 15 | 6 | 3 | 0 | **3.84** |
| | | | | | | **Average** | **4.09 (81.8%)** |

The above Table 37 indicates that the average Intensity Index is 4.09 for the statements related to the aspects that have been understood by the students on account of the implementation of the Instructional Package. The high Intensity Index shows that 81.8% of the students have clearly understood all the concepts related to 'Real Numbers' along with the holistic meaning and structure of the Numbering system as a whole. They have understood the inter-connections between the different sub-topics of Real numbers and have stated that they have got a better understanding about some mathematical facts which were not clear to them earlier. Though the Intensity Index is comparatively lesser for statement 11 (II = 3.84), but most of the students have accepted that they understood complex aspects of Mathematics like estimation, proofs, verification and generalization with respect to the content 'Real numbers'.

### 5.3.3 Analysis and interpretation of students' reaction on their feelings/perceptions towards the unit 'Real Numbers' and towards the subject of Mathematics

Tabulated below are the statements that allow students to reflect on their feelings towards the unit 'Real Numbers' and the subject of Mathematics due to the application of the Instructional Package on them. The number of students who Strongly agreed, Agreed, Not

Decided, Disagreed, and Strongly Disagreed for respective statements are shown in the Table 38, and Intensity Index for each is computed.

**Table 36: Students' reaction on their feelings/perceptions towards the unit 'Real numbers' and towards the subject of Mathematics**

| No. | Statements | SA | A | ND | DA | SD | II |
|---|---|---|---|---|---|---|---|
| **12** | I paid less attention to the concepts explained beyond the textbook. (Negative) | 0 | 7 | 9 | 8 | 7 | **3.48** |
| **13** | I am motivated and interested to learn more about Real numbers and other Numbering systems. | 13 | 17 | 0 | 1 | 0 | **4.35** |
| **14** | I am more confident now to proceed further with the other mathematical topics in my syllabus. | 12 | 18 | 1 | 0 | 0 | **4.35** |
| **15** | I love Mathematics more now. | 10 | 8 | 11 | 2 | 0 | **3.84** |
| **16** | Mathematics seems to be more difficult and complex now. (Negative) | 2 | 5 | 8 | 13 | 3 | **3.32** |
| | | | | | | | **Average 3.87 (77.4%)** |

The above Table 38 indicates that the average Intensity Index is 3.87 for the statements related to the students' feelings or perception towards the content Real numbers and towards Mathematics as a whole after the implementation of the Instructional Package. It indicates that on an average 77.4% of the students responded that they were motivated and interested to learn more about Real numbers; they were more confident to proceed further with other topics and they loved Mathematics more now. Most of them stated that they paid attention even to the topics that went beyond the textbook and for very few (15%) Mathematics seemed to be more difficult and complex now.

### 5.3.4 Analysis and interpretation of students' reaction on the worksheets solved during the intervention period

Tabulated below are the statements that allow students to reflect on the Worksheets solved by them during the intervention period. The number of students who Strongly agreed, Agreed, Not Decided, Disagreed, and Strongly Disagreed for respective statements are shown in the Table 39, and Intensity Index for each is computed.

**Table 37: Students' reaction on the Worksheets solved during the intervention period**

| No. | Statements | SA | A | ND | DA | SD | II |
|---|---|---|---|---|---|---|---|
| **17** | Solving the worksheets increased my understanding about that topic. | 14 | 15 | 2 | 0 | 0 | **4.39** |
| **18** | The worksheets were appropriate and interesting. | 8 | 21 | 2 | 0 | 0 | **4.19** |
| **19** | The worksheets gave me scope to observe patterns and generalize. | 6 | 20 | 4 | 1 | 0 | **4.0** |
| **20** | I could not understand the language used in the worksheets. (Negative) | 1 | 4 | 3 | 14 | 9 | **3.84** |
| **21** | There should have been lesser number of worksheets. (Negative) | 1 | 1 | 11 | 12 | 6 | **3.68** |
| | | | | | | **Average** | **4.02 (80.4%)** |

The above Table 39 indicates that the average Intensity Index is 4.02 for the statements related to students' reaction on the Worksheets given to them as a part of the Instructional Package. It indicates that on an average 80.4% of the students stated that solving the Worksheets increased their understanding about the topic. According to them the Worksheets were appropriate and interesting and gave them a chance to observe patterns and generalize. Most of them understood the language of the Worksheets and found the number of Worksheets appropriate.

### 5.3.5 Analysis and interpretation of students' reaction on the formative assessments- Evaluation1 and Evaluation 2

Tabulated below are the statements that allow students to reflect on the Formative Assessments- Evaluation 1 & 2 given to them during the Package implementation. The number of students who Strongly agreed, Agreed, Not Decided, Disagreed, and Strongly Disagreed for respective statements are shown in the Table 40, and Intensity Index for each is computed.

**Table 38: Students' reaction on the Formative assessments: Evaluation1 & Evaluation 2**

| No | Statements | SA | A | ND | DA | SD | II |
|---|---|---|---|---|---|---|---|
| **22** | New, complex, unfamiliar problems posed in the Evaluations gave me scope to think at higher levels. | 9 | 15 | 5 | 0 | 2 | **3.94** |
| **23** | The Evaluations motivated me to understand concepts of Mathematics rather than memorizing the procedure. | 10 | 16 | 4 | 0 | 1 | **4.10** |
| **24** | The Evaluation questions were very tough and I have lost interest in Mathematics because of them. (Negative) | 3 | 3 | 4 | 10 | 11 | **3.74** |
| | | | | | | | **Average 3.92 (78.4%)** |

The above Table 40 indicates that the average Intensity Index is 3.92 for the statements related to the reaction of students related to the formative assessments of Evaluation 1 and Evaluation 2. This Index indicates that on an average 78.4% of the students responded that the Evaluations gave scope to them to think at higher levels and motivated them to understand concepts rather than memorizing them. The Intensity Index 3.74 for statement 24, indicates that around 75% students did not find the Evaluation questions very tough.

### 5.3.6 Analysis and interpretation of students' reaction on the overall Instructional Package and its implementation

Tabulated below are the statements that allow students to reflect on the Instructional Package and its implementation. The number of students who Strongly agreed, Agreed, Not Decided, Disagreed, and Strongly Disagreed for respective statements are shown in the Table 41, and Intensity Index for each is computed.

**Table 39: Student's reaction on the overall Instructional Package and its implementation**

| No. | Statements | SA | A | ND | DA | SD | II |
|---|---|---|---|---|---|---|---|
| **25** | The teaching, worksheets, evaluations helped me to look at Mathematics in a different way, which is logical, inter-connected and interesting. | 13 | 16 | 2 | 0 | 0 | **4.35** |
| | | | | | | | **(87%)** |

The above Table 41 indicates that the Intensity Index is 4.35 for the statement 25 regarding the reaction on the overall Instructional Package and its implementation. This Index indicates that on an average 87% of the students found that the teaching, Worksheets and Evaluations helped them to look at Mathematics in a different way, which was logical, inter-connected and interesting.

## 5.4 Findings of the Study

The analysis and the interpretation of the data obtained from the Posttest responses of the students of the Experimental and the Control group proves the effectiveness of the Instructional Package over the Conventional method of teaching with respect to 'higher order thinking skills' and 'achievement scores' of students of class IX in the content 'Real Numbers'. The same can be indicated from the following findings.

### 5.4.1 Findings from the analysis of higher level competencies

1. Number of students who have achieved Higher level competencies of Comprehension level- like understanding of information, grasping of meaning, interpretation of facts, compare, contrast, order, group- *completely* in Experimental group was 27.5% in comparison to 5.1% in Control group and *partially* was 37.3% in Experimental group in comparison to 32.4% in Control group.
2. Number of students who have achieved Higher level competencies of Application level - like use of information, use of methods, concepts, theories in new situations to solve problems or make inferences- *completely* in Experimental group was 13.5% in comparison to 1% in Control group and *partially* was 33.6% in Experimental group in comparison to 14.7% in Control group.
3. Number of students who have achieved Higher level competencies of Analysis level - like identification of components, organisation of the components, recognition of hidden meaning to solve problem- *completely* in Experimental group was 9.7% in comparison to 1% in Control group and *partially* was 20.5% in Experimental group in comparison to 9.4% in Control group.
4. Number of students who have achieved Higher level competencies of Synthesis level - like use old ideas to create new ones, generalize from given facts, relate knowledge from several areas, and draw conclusions- *completely* in Experimental group was 7.2% in comparison to 0% in Control group and *partially* was 32.5% in Experimental group in comparison to 6.1% in Control group.
5. Number of students who have achieved Higher level competencies of Evaluation level - like comparison and discrimination between ideas, making choices based on reasoned

argument and verification of value- *completely* in Experimental group was 7.5% in comparison to 1% in Control group and *partially* was 22.6% in Experimental group in comparison to 3.1% in Control group.

The above results prove the effectiveness of the Instructional Package over the Conventional method of teaching with respect to Higher level competencies in the content 'Real Numbers' for class IX students.

**5.4.2 Findings from the analysis basic level competencies**

1. Number of students who have achieved Basic level competencies of Comprehension level - like identification and application of concepts, theories and rules; calculations; and algorithmic procedure-*completely* in Experimental group was 49.5% in comparison to 25% in Control group.
2. Number of students who have achieved Basic level competencies of Application level- like identification and application of concepts, theories and rules; calculations; and algorithmic procedure-*completely* in Experimental group was 38.6% in comparison to 9.3% in Control group.
3. Number of students who have achieved Basic level competencies of Analysis level - like identification and application of concepts, theories and rules; calculations; and algorithmic procedure-*completely* in Experimental group were 24.7% in comparison to 5.2% in Control group.
4. Number of students who have achieved Basic level competencies of Synthesis level - like identification and application of concepts, theories and rules; calculations; and algorithmic procedure-*completely* in Experimental group were 26% in comparison to 8.3% in Control group.
5. Number of students who have achieved Basic level competencies of Evaluation level - like identification and application of concepts, theories and rules; calculations; and algorithmic procedure-*completely* in Experimental group were 16% in comparison to 2% in Control group.

The above results prove the effectiveness of the Instructional Package over the Conventional method of teaching with respect to Basic level competencies in the content 'Real Numbers' for class IX students.

**5.4.3 Findings from the analysis of the t-test result of the Posttest at individual cognitive levels of -Comprehension, Application, Analysis, Synthesis and Evaluation**

1. There was a significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional Package over the ones exposed to the Conventional

method of teaching for HOTS questions at the Comprehension level in the content 'Real Numbers', with the obtained 't' value 3.68 greater than the table value 2.04 at 0.05 level ($p<0.05$).

2. There was a significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional Package over the ones exposed to the Conventional method of teaching for HOTS questions at the Application level in the content 'Real Numbers', with the obtained 't' value 3.56 greater than the table value 2.04 at 0.05 level ($p<0.05$).
3. There was a significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional Package over the ones exposed to the Conventional method of teaching for HOTS questions at the Analysis level in the content 'Real Numbers', with the obtained 't' value 3.18 greater than the table value 2.04 at 0.05 level ($p<0.05$).
4. There was a significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional Package over the ones exposed to the Conventional method of teaching for HOTS questions at the Synthesis level in the content 'Real Numbers', with the obtained 't' value 3.80 greater than the table value 2.04 at 0.05 level ($p<0.05$).
5. There was a significant difference between the Mean Achievement scores of the class IX students exposed to the Instructional Package over the ones exposed to the Conventional method of teaching for HOTS questions at the Evaluation level in the content 'Real Numbers', with the obtained 't' value 3.00 greater than the table value 2.04 at 0.05 level ($p<0.05$).

The results indicate that the students exposed to the Instructional Package performed better in Achievement test that focused on questions requiring higher order thinking abilities, than that of the students exposed to the Conventional Method with respect to the cognitive levels – Understanding, Application, Analysis, Synthesis and Evaluation.

### 5.4.4 Findings from the analysis of the t-test result of the achievement scores of the Posttest at all cognitive levels

There was a significant difference between the Mean Achievement Scores of the students exposed to the Instructional Package over the ones exposed to the Conventional Method of teaching for HOTS questions of all levels in the content 'Real Numbers', as the obtained 't' value 4.53 was greater than that of the table value 2.04 at 0.05 level ($p<0.05$).

So, the students exposed to the Instructional Package performed better in Achievement Test (Posttest) that focused on questions requiring higher order thinking skills, than the students exposed to the Conventional method of teaching.

### 5.4.5 Findings from the analysis of the Reaction scale

***1. Students' reaction on the Instructional strategies implemented in the classroom:***

The average Intensity Index was 4.25 for the statements related to the Instructional strategies like discussion of previous knowledge with reference to each sub-topic; detailed in-depth explanation of each concept; use of examples, counter-examples, contrasts, similarities in explanations; use of questioning technique to promote thinking; resequencing the topics for better links and holistic understanding; and enough time given for each sub-topic helped the students to understand the topic 'Real numbers' better than the usual form of teaching.

***2. Students' reaction on their understanding on the different concepts and processes of the unit 'Real Numbers':***

The average Intensity Index is 4.09 for the respective statements indicate that students have clearly understood all the concepts related to 'Real Numbers' along with the holistic meaning and structure of the Numbering system. They have understood the inter-connections between the different sub-topics of Real numbers. The Intensity Index is comparatively less for statement 11 (II = 3.84), indicating that some of the students have accepted that they understood complex aspects of Mathematics like estimation, proofs, verification and generalization with respect to the content 'Real numbers'.

***3. Students' reaction on their feelings/perceptions towards the unit 'Real numbers' and towards the subject of Mathematics as a whole:***

With an Intensity Index of 4.35, most of the students felt motivated and confident with the topic Real number and to go ahead with the further topics; but with an Intensity Index of 3.38, some students still feel Mathematics to be a difficult and complex subject.

***4. Students' reaction on the Worksheets solved during the intervention period:***

The average Intensity Index is 4.02 for the statements related to students' reaction on the Worksheets indicated that most of the students believed that the worksheets helped them to understand the topic and gave them chance to observe patterns and generalize.

***5. Students' reaction on the Formative assessments - Evaluation1 and Evaluation 2:***

The average Intensity Index is 3.92 for the statements related to the reaction of students related to the formative assessments indicated that the Evaluation 1 and Evaluation 2 gave scope to them to think at higher levels and motivated them to understand concepts rather than memorizing them.

***6. Student's reaction on the overall Instructional Package and its implementation:***

The Intensity Index is 4.35 for the statement regarding the reaction on the overall Instructional Package and its implementation indicated that most of the students found that the teaching, Worksheets and Evaluations helped them to look at Mathematics in a different way, which was logical, inter-connected and interesting.

The comparison of the Experimental and the Control group in terms of Higher level thinking competencies as mentioned in Table 30 clearly indicates that more number of students of the Experimental group have achieved comprehension, application, analysis, synthesis and evaluation competencies with respect to the content Real numbers than those of the Control group. Also the overall Mean of Posttest scores of Experimental group (15.97) was greater than that of the Mean of Posttest scores of Control group (7.17). This proves the effectiveness of the Instructional Package over the Conventional method of teaching. But the study also proves that the analysis, synthesis and evaluation skills could be 'completely' developed in a small number of students - 9.2%, 7.2% and 7.5% respectively, though acquisition of the same was 'partially' seen on a good number (20.5%, 32.5%, 30.6%). But even a minuscule development in such complex cognitive competencies is a considerable one.

The following Chapter includes the Summary of the research Study reported so far. It includes a brief on some observations made by the researcher regarding students' understanding and achievement on the specific topics taught through the Instructional Package and a comprehensive discussion for the overall Study. It also includes suggestions for Mathematics teachers, policy makers and future researchers with respect to the present Study.