

**CHAPTER 4**  
**DATA ANALYSIS, RESULTS AND INTERPRETATION**

**4.0 INTRODUCTION**

This chapter deals with the data analysis and interpretation of the data. Data analysis was done to reach an unbiased conclusion from the collected data. For the analysis of the data in reference to the following objectives, Mean, Standard deviation, Mann-Whitney U test, Spearman’s rho ( $\rho$ ) and intensity analysis were used. In the present study, the Mann-Whitney U test is the most suitable test for analysing the collected data because in the present study, the sampling technique was purposive sampling, and the data did not follow the assumptions of normality. Findings of Objectives one to four are discussed in chapter three.

**4.1 TEST OF NORMALITY**

To attain the objectives of the study, first of all, the researcher has checked the normality of the data. That has given the insight that which test is appropriate for analysing the data.

**4.1.1 Normality Test through Kolmogorov-Smirnov (K-S) Test:**

**Table 4.1: Tests of Normality**

Variable	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
<b>Cognitive Load</b>	.066	100	.05	.987	100	.437
<b>Achievement</b>	.124	100	.05	.951	100	.001

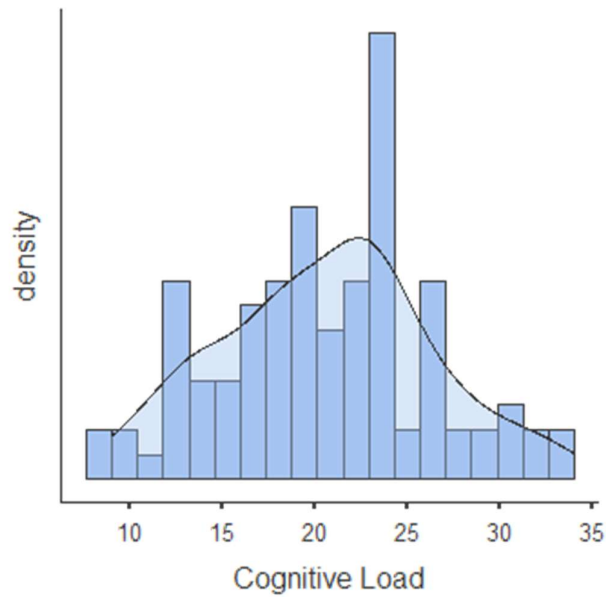
**Interpretation of the Normality test:**

For the present set of data, N is greater than 50 (N = 100); therefore, the Kolmogorov-Smirnov (K-S) test is more appropriate (Demir, 2022). On the other hand, if N = 50 or N < 50, then the Shapiro-Wilk and Anderson-Darling tests give a more reliable result (Ahad et al., 2011; Kundu et al., 2011).

**4.1.1.1 For Cognitive Load:**

**Kolmogorov-Smirnov (K-S) Test:** The statistic is 0.066 with N = 100, and the significance level is 0.05. Since the significance level is greater than 0.05. This

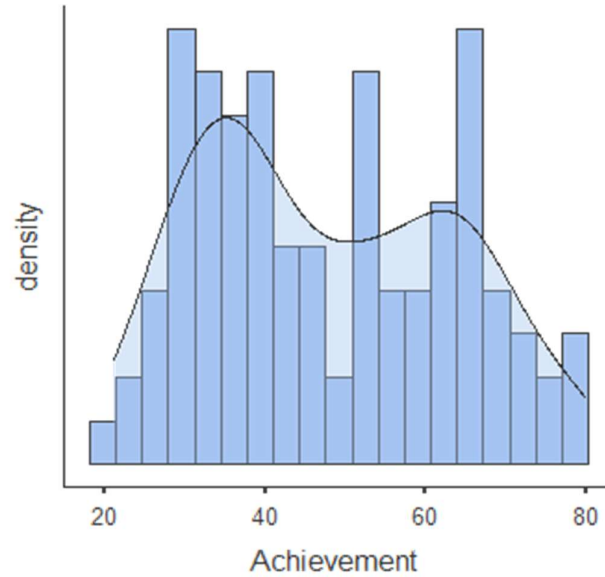
suggests that the distribution of cognitive load scores does not significantly deviate from normality according to the Kolmogorov-Smirnov test.



**Figure 4.1: Distribution of Cognitive Load Scores**

#### **4.1.1.2 For Achievement:**

Kolmogorov-Smirnov (K-S) Test: The statistic is 0.124 with 100 degrees of freedom. With a significance level of less than 0.05. This indicates that the distribution of achievement scores significantly deviates from normality according to the Kolmogorov-Smirnov test.



**Figure 4.2: Distribution of Achievement Scores**

#### 4.1.2 Normality Test through Skewness

This is a method in which the normality is decided by the ratio of skewness and standard error.

**Table 4.2: Value of Skewness and Kurtosis**

Variable		Statistic (d)	Std. Error	d/Std. Error
<b>Cognitive Load</b>	Skewness	.063	.241	.261
	Kurtosis	-.394	.478	.824
<b>Achievement</b>	Skewness	.260	.241	1.07
	Kurtosis	-1.111	.478	-2.32

#### Interpretation of Skewness and Kurtosis

##### 4.1.2.1 For Cognitive Load:

**Skewness:** The skewness value is 0.063 with a standard error of 0.241. The ratio of skewness to its standard error is approximately 0.261. Since the ratio is close to zero, it suggests that the skewness is not substantially different from zero, indicating that the distribution is approximately symmetrical.

**Kurtosis:** The kurtosis value is -0.394 with a standard error of 0.478. The ratio of kurtosis to its standard error is approximately -0.824. This suggests that the kurtosis is

not substantially different from zero, indicating that the distribution is approximately mesokurtic (neither peaked nor flat).

The Cognitive Load variable appears to have an approximately symmetrical distribution with moderate skewness and kurtosis close to zero, indicating a distribution close to normal.

**4.1.2.1 For Achievement:**

**Skewness:** The skewness value is 0.260 with a standard error of 0.241. The ratio of skewness to its standard error is approximately 1.07. Since the ratio is greater than 1, it suggests that the skewness is relatively large compared to its standard error, indicating a moderate degree of skewness in the distribution.

**Kurtosis:** The kurtosis value is -1.111 with a standard error of 0.478. The ratio of kurtosis to its standard error is approximately -2.32. Since the ratio is substantially less than -2, it suggests that the kurtosis is significantly different from zero, indicating a distribution that is platykurtic (flatter than a normal distribution).

Hence, it was found that the data is not normally distributed; therefore, the Mann-Whitney U test is the most appropriate test for comparing the mean difference between the groups.

The Achievement variable shows moderate skewness and significant kurtosis, indicating a deviation from normality.

**4.2 Objective 5: To study academic achievement in science among secondary students.**

Hear, the descriptive properties of the scores (academic achievement) have been presented by the researcher.

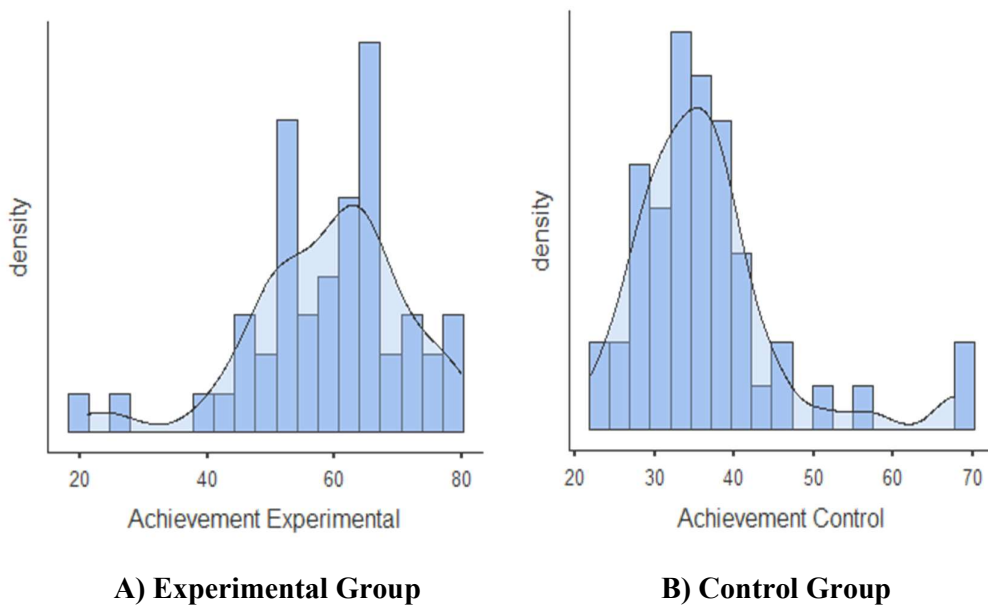
**Table 4.3: Descriptive Properties of Academic Achievement Score**

Groups	N	Minimum	Maximum	Mean	Std. Deviation
Control	50	22	68	36.26	9.337
Experimental	50	21	80	59.08	12.160

**Result:**

Both groups have a sample size of 50. This was the number of individuals or observations included in each group. For the Achievement Control group, the

minimum score is 22. For the Achievement Experimental group, the minimum score was 21. These were the lowest scores observed in each group. On the other hand, the maximum score in the Achievement Control group was 68. The maximum score in the Achievement Experimental group was 80. These were the highest scores recorded in each group. The average score for the Achievement Control group is 36.26. The average score for the Achievement Experimental group is 59.08. The mean scores indicate the average performance of each group, with the experimental group performing higher on average. The standard deviation for the Achievement Control group is 9.337. The standard deviation for the Achievement Experimental group is 12.160. Standard deviation measures the amount of variation or dispersion of scores in each group. A higher standard deviation indicates that the scores are more spread out from the mean, suggesting greater variability in performance within the experimental group compared to the control group.



**Figure 4.3: Academic Achievement Scores**

The above graph (Figure 4.3) shows the spread and accumulation of the data. It shows that the majority of scores are accumulated around the sixty marks for the experimental group, but in the case of the control group, the majority of scores are accumulated between thirty to forty marks.

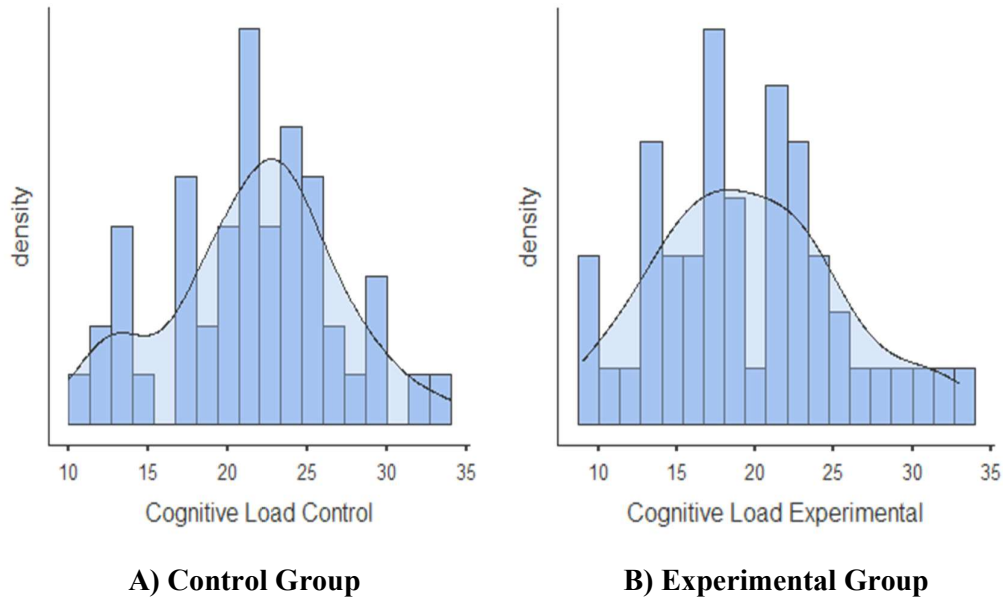
### 4.3 Objective 6: To study the cognitive load in science among secondary students.

Table no. 4.4 shows the descriptive properties of the scores of the cognitive load.

**Table 4.4: Descriptive Properties of Cognitive Load**

<b>Groups</b>	<b>N</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Std. Deviation</b>
<b>Control</b>	50	10	34	21.66	5.355
<b>Experimental</b>	50	9	33	19.58	5.852

The key statistical measures for two distinct groups involved in a study evaluating cognitive load: the "Cognitive Load Control group" and the "Cognitive Load Experimental group." Each group comprises 50 participants (N=50). The minimum cognitive load score in the Control group is 10. The minimum cognitive load score in the Experimental group is 9. These values represent the lowest level of cognitive load recorded among the participants in each group. The maximum cognitive load score in the Control group is 34. The maximum cognitive load score in the Experimental group is 33. These values indicate the highest level of cognitive load experienced by any participant within each respective group. The mean cognitive load for the Control group is 21.66. The mean cognitive load for the Experimental group is 19.58. The mean provides a measure of the central tendency of cognitive load scores within each group, indicating that, on average, the Control group experienced a higher cognitive load compared to the Experimental group. The standard deviation for the Cognitive Load Control group is 5.355. The standard deviation for the Cognitive Load Experimental group is 5.852. This statistic quantifies the variability or dispersion of the cognitive load scores around their respective means. A higher standard deviation, as observed in the Experimental group, suggests a broader spread of scores, indicating greater heterogeneity in how participants experienced cognitive load.



**Figure 4.4: Cognitive Load Scores**

The above graph (Figure 4.4) shows the spread and accumulation of the scores. It shows that the majority of scores are spread from fifteen to twenty-five for the experimental group, but in the case of the control group, the majority of scores are accumulated between twenty to twenty-five.

**4.4 Objective 7: To examine the effectiveness of the developed constructivist pedagogical intervention in terms of the enhancement of academic achievement in science among secondary students.**

**H<sub>01</sub>:** There is no significant difference between the mean gain score of the post-test on achievement between the experimental and control groups at the 0.05 level of significance.

**Table 4.5: Mann-Whitney U Test on Achievement**

Groups	N	Mean Rank	Sum of Ranks	U-value	Z-value	p-value	Effect Size
Control	50	29.65	1482.50	207.500	-7.189	.001*	.834
Experimental	50	71.35	3567.50				
<b>* Significant at 0.05 <math>\alpha</math></b>							

**Result and Interpretation:**

The experimental group has a much higher mean rank (71.35) compared to the control group (29.65). This suggested that the experimental group's achievement scores were

generally higher than those of the control group. In the case of the Mann-Whitney U test, if the N is less than 20, then we make the judgment based on the U-value, but if N is greater than 20, then we look for the z-value. In the case of the z-value, if it lies between  $\pm 1.96$  to  $\pm 2.56$ , then U is significant at the 0.05 level of significance, and if the z-value exceeds  $\pm 2.56$ , then the U-value is significant at the 0.01 level of significance. Here, the U-value of 207.500 and the corresponding z-value of -7.189; hence, U was significant at the 0.01 level of significance, and it indicated that the difference between the control and experimental groups was statistically significant. In this continuum, the p-value of .001 is much smaller than the significance level of 0.05, confirming that the difference between the groups is highly significant. This leads us to the rejection of the null hypothesis, which stated that there was no significant difference between the groups. The result shows that academic achievement is not the same across the groups, but the experimental group has higher academic achievement than the control group. An effect size of .834 is considered large, implying that the experimental intervention had a strong impact on achievement scores. The histogram plots (Figure 4.3) supported the statistical findings from the Mann-Whitney U test and highlighted that there was a significant difference in the distribution of achievement scores between the experimental and control groups. The experimental group not only had higher scores on average but also exhibited greater variability, which depicted a more pronounced effect of the experimental treatment.

**4.5 Objective 8. To examine the effectiveness of the developed constructivist pedagogical intervention in terms of reducing cognitive load in science among secondary students.**

**H<sub>02</sub>:** There is no significant difference between the mean gain score of the post-test on cognitive load between the experimental and control groups at the 0.05 level of significance.

**Table 4.6: Mann-Whitney U Test on Cognitive Load**

Groups	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z-Value	p-Value	Effect Size
Control	50	56.35	2817.50	957.500	-2.020	0.043*	0.234
Experimental	50	44.65	2232.50				
<b>*Significant at 0.05 <math>\alpha</math></b>							

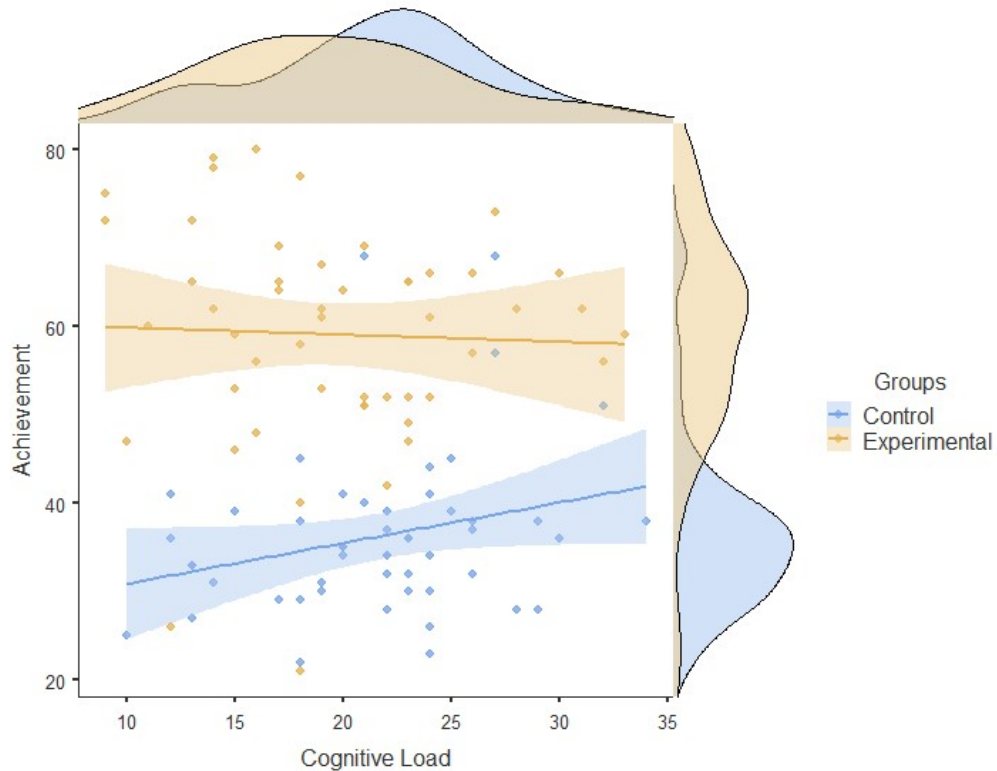
**Result and Interpretation:**

N represented the sample size, which is 100. The Mann-Whitney U test value was the measure of the rank sum of the scores in the two groups. In the present situation, it's 957.500, and the Z-value was the test statistic derived from the U-statistic. It was -2.020. In the case of the Mann-Whitney U test, if the N is less than 20, then we make the judgment based on the U-value, but if N is greater than 20, then we look for the z-value. In the case of the z-value, if it lies between  $\pm 1.96$  to  $\pm 2.56$ , then U is significant at the 0.05 level of significance. Since the z-value (-2.020) lies between  $\pm 1.96$  to  $\pm 2.56$  (two-tailed test), and the significance level is 0.05. Therefore, the U was significant at the 0.05 level of significance. Hence, there's a significant difference between the cognitive load scores of the two groups. The mean rank of the control group was higher than the experimental group, revealing that the control group experienced more cognitive load than the experimental group. The effect size was 0.234, it was a moderate level of effect size that revealed that the intervention programme has a moderate effect on reducing the cognitive load in the students. The histogram plots (Figure 4.4) supported the statistical findings from the Mann-Whitney U test and highlighted that there was a significant difference in the distribution of cognitive load scores between experimental and control groups.

**4.6 Objective 9: To study the relationship between academic achievement and cognitive load in science among secondary students.**

Here, figure no. 4.5 represents the relationship between academic achievement and cognitive load.

**Visualization of Data through Scattered Plot**



**Figure 4.5: Relationship Between Cognitive Load Scores and Achievement Scores**

**Interpretation of the Scatter Plot with Density Marginals**

The scatter plot with density marginals displays the relationship between cognitive load and achievement for both the control and experimental groups.

**Axes:**

X-Axis: Cognitive Load

Y-Axis: Achievement

**Groups:**

Control Group: Represented in blue

Experimental Group: Represented in Pink

**Trend Lines:***Control Group (Blue):*

The trend line shows a slight positive slope, indicating a minor positive correlation between cognitive load and achievement.

*Experimental Group (Pink):*

The trend line sloped downward, which indicated a significant correlation between cognitive load and achievement.

**Density Marginals:**

Top Density Plot: Represents the distribution of cognitive load for both groups.

The experimental group's cognitive load was slightly lower on average than the cognitive load of the control group.

Right Density Plot: Represents the distribution of achievement scores for both groups.

The experimental group generally has higher achievement scores compared to the control group.

**Key Observations:****Cognitive Load Distribution:**

The experimental group tends to have a lower cognitive load compared to the control group, as indicated by the top-density plot.

**Achievement Distribution:**

The experimental group shows higher achievement scores, as observed in the right density plot.

**Correlation:**

For the control group, a slight positive correlation (Spearman's rho ( $\rho$ ) = 0.237,  $df$  = 48,  $p$  = .09) was observed, although it was not statistically significant. This suggests that as cognitive load increases, achievement scores tend to increase slightly. On the other hand, for the experimental group, the downward slope of the line with increasing cognitive load suggested a negative correlation (Spearman's rho ( $\rho$ ) = -0.099,  $df$  = 48,  $p$  = 0.49). However, this correlation was not statistically significant in relation to achievement.

**Conclusion:**

**Experimental Group:** The intervention seems to maintain higher achievement levels and reduce the cognitive load in the experimental group.

**Control Group:** Achievement is slightly positively correlated with cognitive load, suggesting that within this group, students with higher cognitive load might achieve

slightly better.

The scatter plot, along with the density marginals, reinforces the earlier findings that the experimental intervention has a significant positive impact on achievement and helped in reducing the cognitive load.

#### 4.7 Objective 10: To examine the reaction of students toward the developed constructivist pedagogical intervention.

The Intensity analysis of the students' response is given below:

**Table 4.7: Students' Reaction Towards Constructivist Pedagogical Intervention**

Sr. no.	Statement	SDA	DA	UD	A	SA	Intensity
1	It helped to promote divergent thinking.	6%	2%	28%	54%	10%	3.6
		3	1	14	27	5	
2	It helped me to think rationally.	4%	6%	18%	50%	22%	3.8
		2	3	9	25	11	
3	It helped me solve problems/questions during the learning process.	4%	16%	10%	50%	22%	3.7
		2	8	5	25	11	
4	It helped me to think creatively.	2%	20%	12%	38%	28%	3.7
		1	10	6	19	14	
5	I want to learn other subjects through this teaching method (CPI).	8%	16%	26%	34%	16%	3.34
		4	8	13	17	8	
6	It raised my interest in learning.	4%	14%	20%	44%	18%	3.58
		2	7	10	22	9	
7	I enjoyed learning Science through this method.	6%	16%	20%	36%	22%	3.52
		3	8	10	18	11	
8	I felt it made learning more enjoyable.	6%	6%	26%	30%	32%	3.76
		3	3	13	15	16	

9	I felt that activities done in groups were interesting.	<b>10%</b>	<b>10%</b>	<b>22%</b>	<b>36%</b>	<b>22%</b>	3.5
		5	5	11	18	11	
10	Through this method, I found the scope of healthy discussion among classmates.	<b>6%</b>	<b>12%</b>	<b>20%</b>	<b>42%</b>	<b>20%</b>	3.58
		3	6	10	21	10	
11	It made learning more interactive.	<b>6%</b>	<b>10%</b>	<b>18%</b>	<b>36%</b>	<b>30%</b>	3.74
		3	9	10	18	10	
12	It gave more scope for interaction with the teacher.	<b>2%</b>	<b>10%</b>	<b>20%</b>	<b>44%</b>	<b>24%</b>	3.78
		1	5	10	22	12	
13	It made the classroom democratic.	<b>6%</b>	<b>10%</b>	<b>20%</b>	<b>44%</b>	<b>20%</b>	3.62
		3	5	10	22	10	
14	I was free to ask questions in the classroom.	<b>2%</b>	<b>6%</b>	<b>20%</b>	<b>38%</b>	<b>34%</b>	3.96
		1	3	10	19	17	
15	I found I was engaged in the class during the teaching.	<b>10%</b>	<b>8%</b>	<b>28%</b>	<b>34%</b>	<b>20%</b>	3.46
		5	4	14	17	10	
16	It promoted a better conceptual understanding of the topic/ the concept of the subject.	<b>6%</b>	<b>14%</b>	<b>18%</b>	<b>52%</b>	<b>10%</b>	3.46
		3	7	9	26	5	
17	It helped me achieve high scores on the examination.	<b>0%</b>	<b>18%</b>	<b>22%</b>	<b>32%</b>	<b>28%</b>	3.7
		0	9	11	16	14	
18	I feel that it helps me in the better expression of my ideas.	<b>4%</b>	<b>6%</b>	<b>20%</b>	<b>44%</b>	<b>26%</b>	3.82
		2	3	10	22	13	
19	This method helped me to produce many new examples of concepts.	<b>0%</b>	<b>14%</b>	<b>30%</b>	<b>36%</b>	<b>20%</b>	3.62
		0	7	15	18	10	

20	This CPI gave more scope for the activity than the lecture method.	2%	12%	24%	40%	22%	3.68
		1	6	12	20	11	
21	Through this method, I found the opportunity to link classroom activity to our daily lives.	2%	12%	18%	54%	14%	3.66
		1	6	9	27	7	
22	I found it helped in the improvement of my self-confidence.	2%	14%	14%	36%	34%	3.87
		1	7	7	18	17	
23	This method helped me to identify my strengths in the subject.	8%	10%	18%	32%	32%	3.70
		4	5	9	16	16	

### **Interpretation of Data Gathered Through Likert Scale Regarding Teaching Method Effectiveness**

This table summarizes responses to various statements regarding the effectiveness of the constructivist pedagogical intervention programme. Responses are categorized as Strongly Disagree (SDA), Disagree (DA), Undecided (UD), Agree (A), and Strongly Agree (SA). The intensity column reflects the average score based on the Likert scale (1 for SDA to 5 for SA).

#### **Overall Intensity:**

The total average intensity score was 3.65, which indicated an overall positive reaction of the students towards the intervention programme.

#### **Statement-wise Intensity Analysis:**

1. 54% agreed, and 10% strongly agreed, indicating a general consensus that “the method promotes divergent thinking”. The total intensity was 3.6, which showed a favourable reaction from the students.
2. 50% agreed, and 22% strongly agreed, with the statement that “the teaching method helped me to think rationally”. The total intensity was 3.8 which showed that the students found the method aids to promote their rational thinking.
3. 50% agreed, and 22% strongly agreed, reflecting that the method is effective in aiding problem-solving during learning. The total intensity of the reaction was 3.7.

4. 38% agreed, and 28% strongly agreed with the statement, “It helped me to think creatively”. The total intensity was 3.7, which revealed that the intervention programme has a positive impact on creative thinking.
5. 34% agreed, and 16% strongly agreed with the statement, “I want to learn other subjects through this teaching method (CPI).” The total intensity was 3.34, which depicted a favourable reaction of the students towards the intervention programme.
6. 44% agreed, and 18% strongly agreed with the statement, “It raised my interest in learning”. The total intensity of the reaction was 5.58, which showed that the intervention programme enhanced the interest in science learning.
7. 36% agreed, and 22% strongly agreed, with the statement “I enjoyed learning Science through this method”. The total intensity of the response was 3.52, which indicated that students enjoyed the teaching and learning through this intervention programme.
8. 30% agreed, and 32% strongly agreed with the statement, “I felt it made learning more enjoyable”. The total intensity was 3.76, which indicated that the intervention programme made learning enjoyable.
9. 36% agreed, and 22% strongly agreed with the statement, “I felt activities done in groups were interesting”. The total intensity of reactions was 3.5, which showed that the group activities during the teaching and learning were interesting.
10. 42% agreed, and 20% strongly agreed, reflecting moderate agreement on the statement, “Through this method, I found the scope of healthy discussion among classmates.” The total intensity of this statement was 3.58, which indicated that the intervention programme promoted healthy discussion among classmates.
11. 36% agreed, and 30% strongly agreed with the statement, “It made learning more interactive.” The total intensity of the reactions was 3.74, which showed that the intervention programmes made learning more interactive.
12. 44% agreed, and 24% strongly agreed with the statement, “It gave more scope for interaction with the teacher”. The total intensity was 3.78, which indicated that the intervention programme has a positive impact on interaction with the teacher.
13. 44% agreed, and 20% strongly agreed with the statement, “It made the classroom more democratic”. The total intensity of reactions was 3.62, which indicated that the intervention programme provided more scope between students and teacher interaction.

14. 38% agreed, and 34% strongly agreed with the statement, “While teaching through CPI, I was free to ask questions in the classroom.” The total intensity was 3.96, which suggested that the method encourages students to ask questions.
15. 34% agreed, and 20% strongly agreed with the statement, “I found I was engaged in the class during the teaching.” The total intensity on this statement was 3.46, which showed an agreement that the method engaged the students in the classroom during teaching.
16. 52% agreed, and 10% strongly agreed with the statement, “It promoted a better conceptual understanding of the topic/ the concept of the subject.” The total intensity of reactions was 3.46, which indicated a positive impact of the intervention programme on conceptual understanding.
17. 32% agreed, and 28% strongly agreed with the statement, “It helped me achieve high scores on the examination.” The total intensity of reactions was 3.7, which showed that the teaching-learning through intervention programme helped in achieving high scores on the examination.
18. 44% agreed, and 26% strongly agreed with the statement, “I feel that it helps me in the better expression of my ideas.” The total intensity was 3.82, which suggested that the intervention programme helped students in expressing their ideas better.
19. 30% agreed, and 36% strongly agreed with the statement, “This method helped me to produce many new examples of concepts”. The total intensity of reactions was 3.62, which indicated that the intervention programme enables students to produce new examples of concepts.
20. The total intensity of reactions was 3.68, which showed a piece of evidence that the intervention programme offered a broad range of activities, which is important for constructivist learning, with 40% agreeing and 22% strongly agreeing with the statement “This CPI gave more scope for the activity than the lecture method”.
21. Connecting learning to real life, crucial for relevance, was well-supported, with 54% agreeing and 14% strongly agreeing with the statement, “Through this method, I found the opportunity to link classroom activity to our daily lives.” The total intensity index was 3.66, which showed that the intervention programme helped to link classroom activities to daily lives.
22. 36% agreed, and 34% strongly agreed with the statement, “I found it helped in the improvement of my self-confidence”. The total intensity of reactions was 3.87,

which indicated that the intervention programme helped students to improve their self-confidence.

23. 32% agreed, and 32% strongly agreed with the statement, “This method helped me to identify my strengths in the subject.” The total intensity of reactions was 3.70, which suggested that the intervention programme helped students to identify their strengths in the subject.

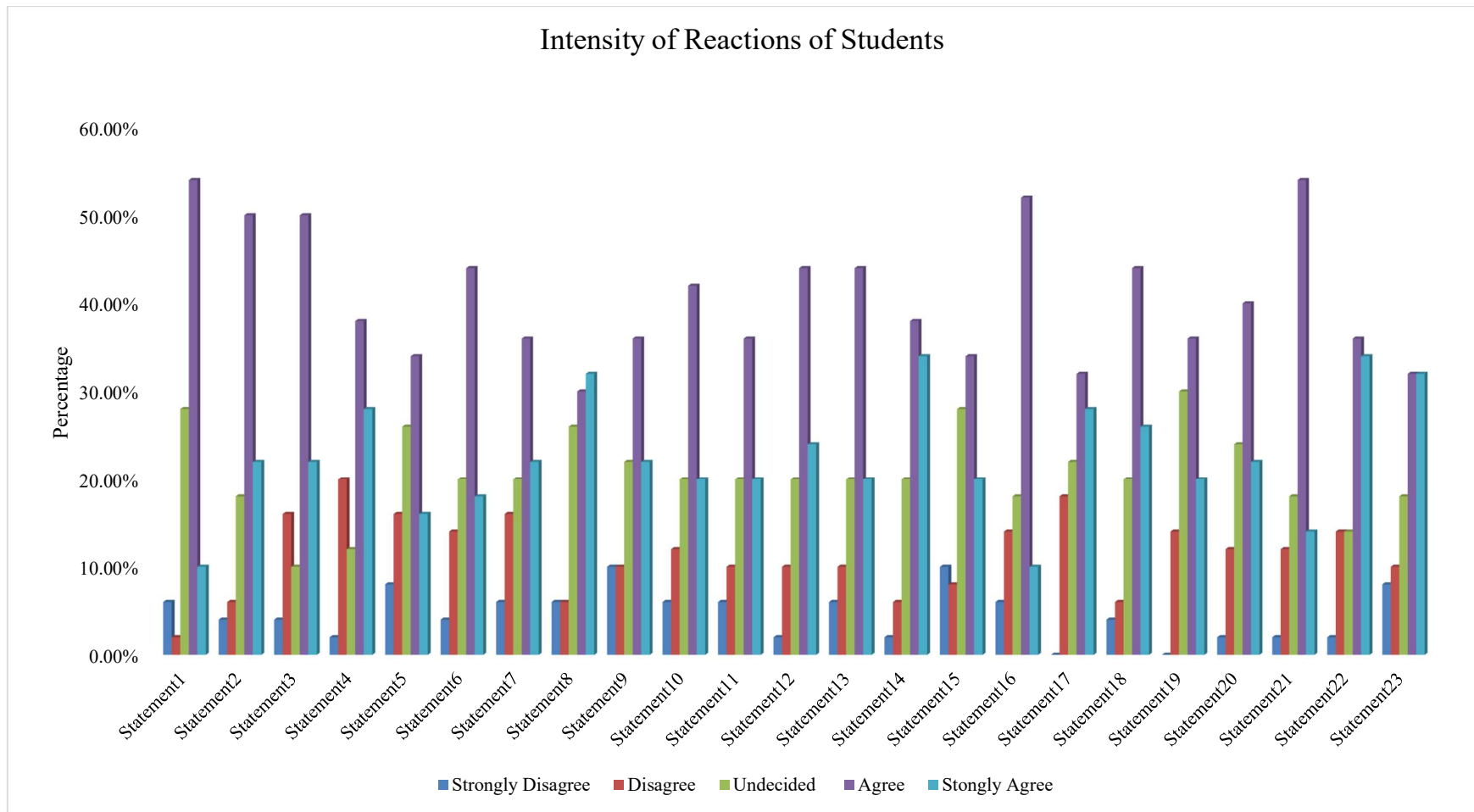
#### **4.8 MAJOR FINDINGS**

1. There is a significant difference between the experimental and control groups concerning their achievement scores at the 0.05 level of significance. The experimental group secured a higher mean (59.08) than the control group (36.26), which was significantly higher than the control group.
2. For the achievement effect size was .834, which depicted a higher level of effectiveness of the intervention programme on the experimental group for enhancement of achievement scores.
3. There is a significant difference between the experimental and control groups concerning their cognitive load at the 0.05 level of significance. The control group secured a higher mean (21.66) than the experimental group (19.58), which was significantly higher than the Experimental group.
4. For the cognitive load effect size was .234 which depicted a moderate level of effectiveness of the intervention programme on the experimental group for reducing the cognitive load.
5. The total average intensity score was 3.65, which indicated an overall positive reaction of the students towards the intervention programme. The data indicated a generally positive perception towards the intervention programme, with high agreement on its effectiveness in engaging students, promoting rational and creative thinking, healthy interaction with peers and teachers, and improving self-confidence. The intervention programme also gave the scope for the students to identify strengths and weaknesses in the subject. The lowest scores still indicate a positive impact, showing overall satisfaction with the method.

#### **4.9 CONCLUSION**

The data indicated a generally positive perception towards the intervention programme, with high agreement on its effectiveness in engaging students, promoting

rational and creative thinking, healthy interaction with peers and teachers, and improving self-confidence. The intervention programme also gave the scope for the students to identify their strengths and weaknesses in the subject. The lowest scores still indicate a positive impact, showing overall satisfaction with the method.



**Figure 4.6: Intensity of Reactions of Students on Developed Constructivist Intervention Programme**