CHAPTER-IV

CHAPTER IV

DATA ANALYSIS AND INTERPRETATION

This chapter provides an overview of data presentation and statistical techniques used to analyze and interpret the results.

4.1 Analysis of data using SPSS

Table 4.1: Descriptive Statistics table showing range, mean, standard deviation, variance, skewness and kurtosis.

	N	Range	Minimum	Maximum	Mean	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Control group pre-test	60	9.50	2.00	11.50	6.4333	.29195
Control group post-test	60	8.00	6.00	14.00	9.3667	.29277
Experimental group pre-test	60	9.00	2.00	11.00	6.4250	.28937
Experimental group post-test	60	8.00	6.00	14.00	10.4833	.27769
Valid N (listwise)	60					

	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Control group pre-test	2.26144	5.114	.450	.309	-.194	.608
Control group post-test	2.26780	5.143	.492	.309	-.573	.608
Experimental group pre-test	2.24141	5.024	-.084	.309	-.793	.608
Experimental group post-test	2.15101	4.627	-.255	.309	-.724	.608

Table 4.1 clearly shows that in the control group, the mean score increased from 6.43 (range: 2.00–11.50) in the pre-test to 9.37 (range: 6.00–14.00) in the post-test, with standard deviations remaining consistent around 2.26, indicating a moderate spread of scores. The skewness values for the control group are positive (0.450 pre-test, 0.492 post-test), suggesting a slight right-skewed distribution. The kurtosis values are -0.194 for pre-test and -0.573 for post-test, indicating a flatter distribution called as platykurtic. For the experimental group, the mean scores increased more substantially from 6.43 (range: 2.00–11.00) in the pre-test to 10.48 (range: 6.00–14.00) in the post-test.

Slight decrease in standard deviation is seen from 2.24 to 2.15, suggesting improved performance with slightly less variability. The skewness values are -0.084 for pre-test and -0.255 for post-test, indicating a slight left-skewed distribution. The control group exhibits a slight right skew, while the experimental group shows a slight left skew in score distributions. The kurtosis values are -0.793 for pre-test and -0.724 for post-test consistent with a platykurtic distribution. The kurtosis values across all tests suggest flatter distributions with fewer extreme values.

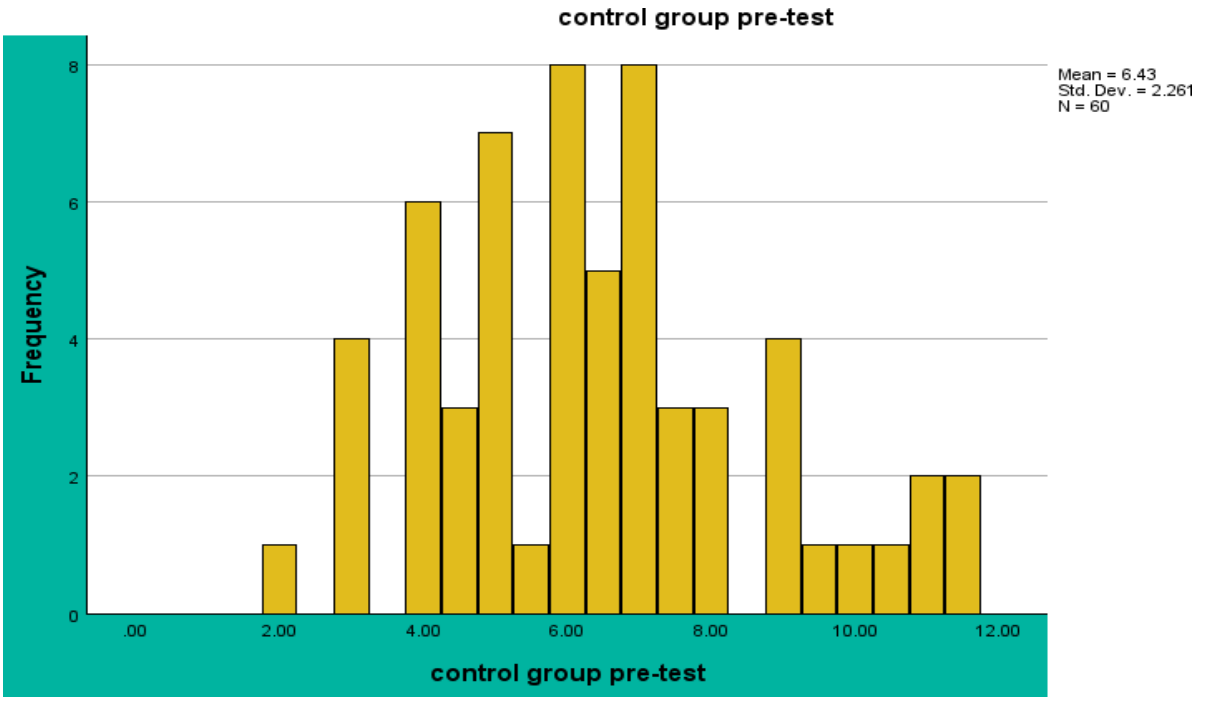
These findings imply that the interventions applied were effective, particularly in the experimental group, and that the data collected are reliable for further statistical analysis.

Table 4.2 Frequency table showing mean, median, mode.

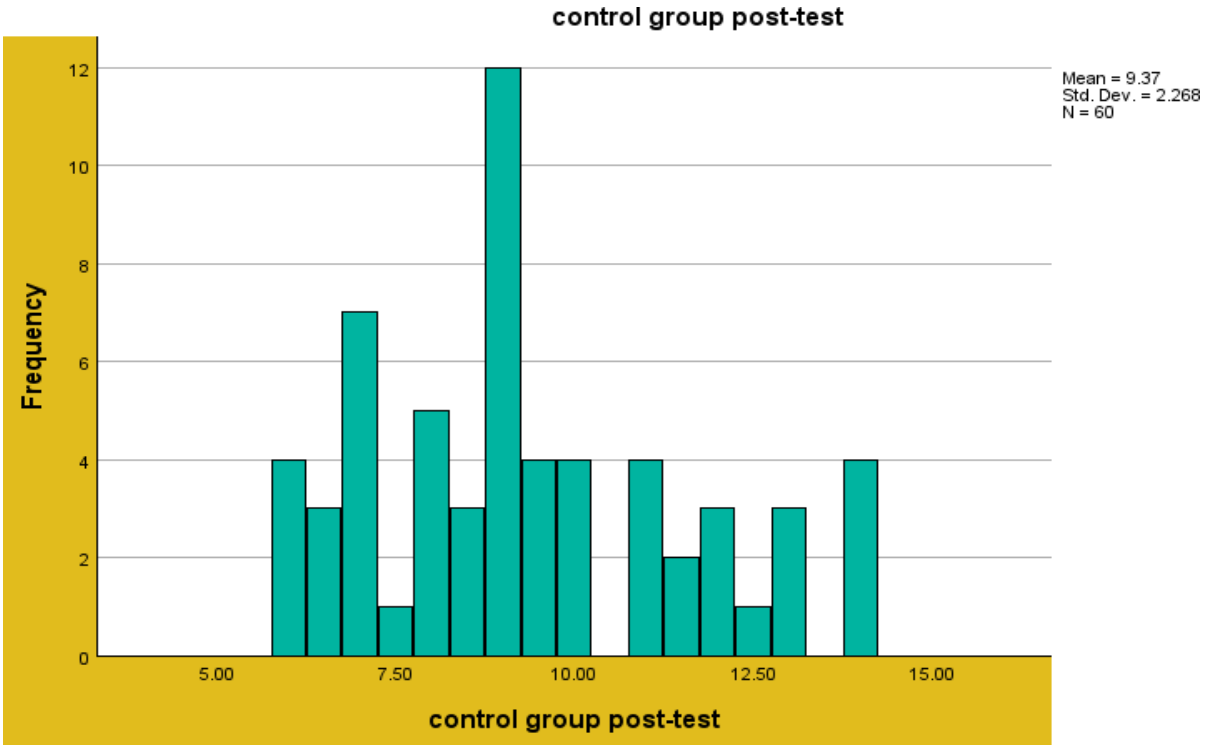
		Control group pre-test	Control group post-test	Experimental group pre-test	Experimental group post-test
N	**Valid**	60	60	60	60
	Missing	0	0	0	0
Mean		6.4333	9.3667	6.4250	10.4833
Std. Error of Mean		.29195	.29277	.28937	.27769
Median		6.2500	9.0000	6.5000	10.0000
Mode		6.00	9.00	6.00	12.00
Std. Deviation		2.26144	2.26780	2.24141	2.15101
Variance		5.114	5.143	5.024	4.627
Skewness		.450	.492	-.084	-.255
Std. Error of Skewness		.309	.309	.309	.309
Kurtosis		-.194	-.573	-.793	-.724
Std. Error of Kurtosis		.608	.608	.608	.608
Range		9.50	8.00	9.00	8.00
Minimum		2.00	6.00	2.00	6.00
Maximum		11.50	14.00	11.00	14.00

From table 4.2, it can be seen that in the control group, the mean score increased from 6.43 (range: 2.00–11.50) in the pre-test to 9.37 (range: 6.00–14.00) in the post-test, with standard deviations remaining consistent around 2.26, indicating a moderate spread of scores. For the experimental group, the mean scores increased more substantially from 6.43 (range: 2.00–11.00) in the pre-test to 10.48 (range: 6.00–14.00) in the post-test, with a slight decrease in standard deviation from 2.24 to 2.15, suggesting improved performance with slightly less variability.

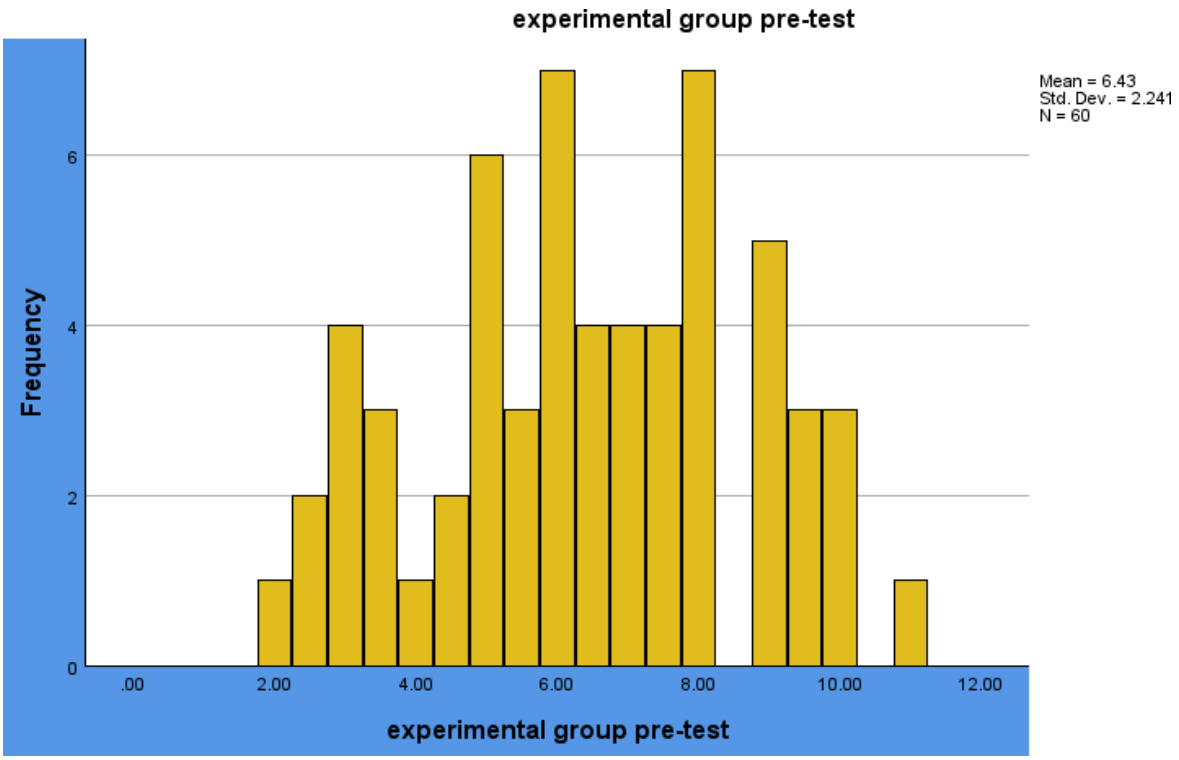
The table suggests that both groups were on an equal footing before the instructional treatment began. Overall, both groups show improvements in mean scores from pre-test to post-test.



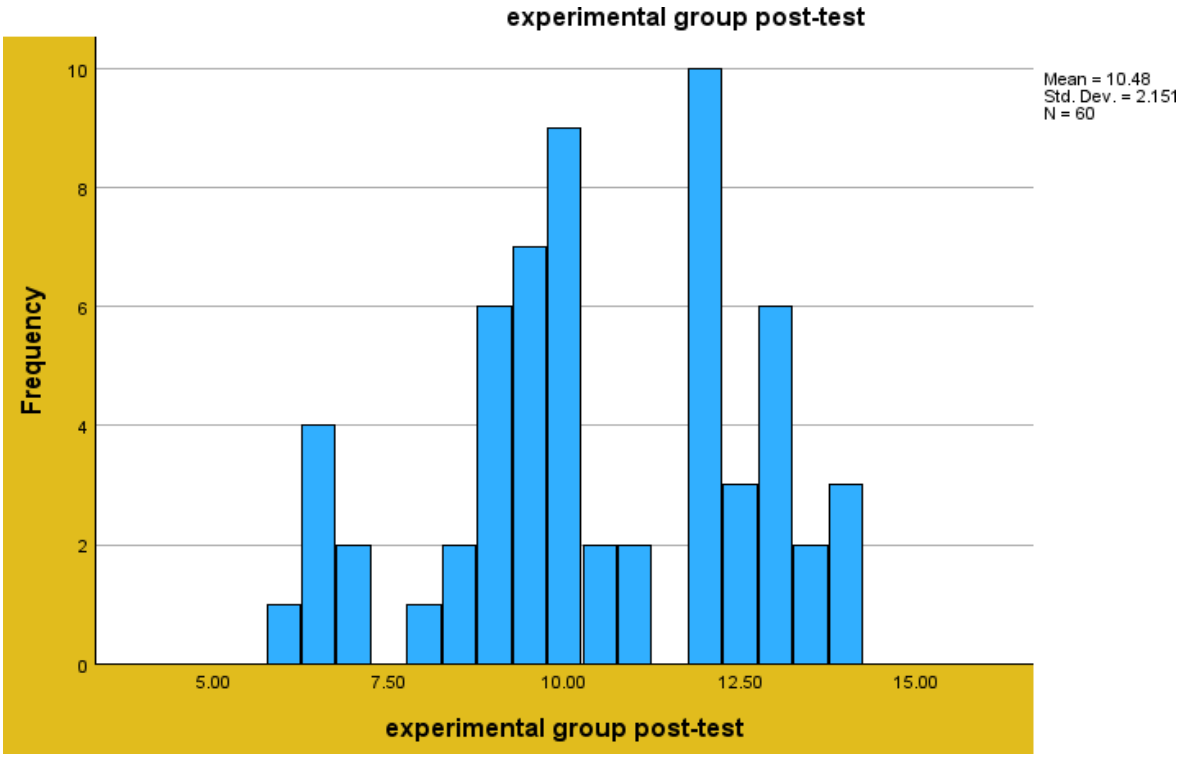
(Figure 4.1: Histogram of Control Group Pre-Test Score Frequency)



(Figure 4.2: Histogram of Control Group Post-Test Score Frequency)



(Figure 4.3: Histogram of Experimental Group Pre-Test Score Frequency)



(Figure 4.4: Histogram of Experimental Group Post-Test Score Frequency

4.2 Hypothesis wise Analysis of data

4.2.1 Hypothesis 1

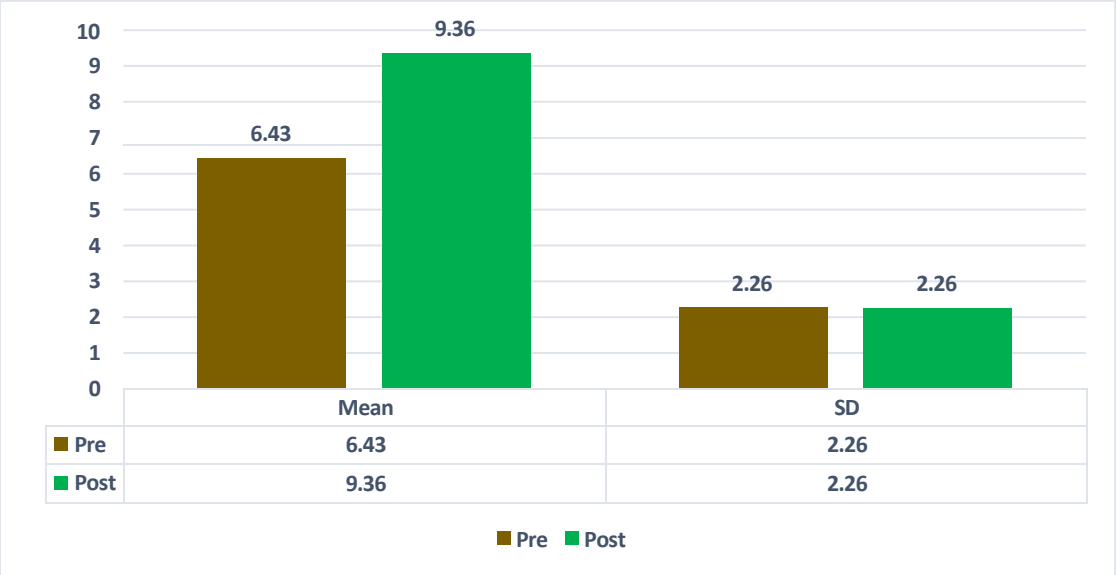
$H_0$1: There is no significant difference between the mean academic achievement scores of pre-test (BSAT-1) and post-test (BSAT-2) of the control group.

Table 4.3: Paired sample t-test for control group with respect to pre-test and post-test

Test	N	Mean	SD	Df	p-value	t-cal	t-crit	Interpretation	Decision
Pre	60	6.43	2.26	59	2.1×10^{-27}	19.24	1.67	Significant	$H_0$1 not Accepted
Post		9.36	2.26						

(Note: N= Sample, SD= Standard Deviation, Df = Degree of Freedom, p= probability value, t-cal = t-calculated, t-crit = t-critical)

A paired-samples t-test had been conducted at the 0.05 level of significance to determine whether a significant difference existed between the mean academic achievement scores of pre-test and post-test within the control group. Table 4.3 shows that the mean score increased from 6.43 (SD = 2.26) in the pre-test to 9.36 (SD = 2.26) in the post-test. The calculated t-value of 19.24 far exceeds the critical t-value of 1.67, and the p-value (2.1×10^{-27}) is substantially below the 0.05 significance level. These results indicate a statistically significant improvement in the students' academic performance, leading to the rejection of the null hypothesis $H_0$1.



(Figure 4.5: Bar graph showing mean academic achievement scores of pre-test and post-test within the control group)

These results revealed that the students' academic achievement was significantly raised.

4.2.2 Hypothesis 2

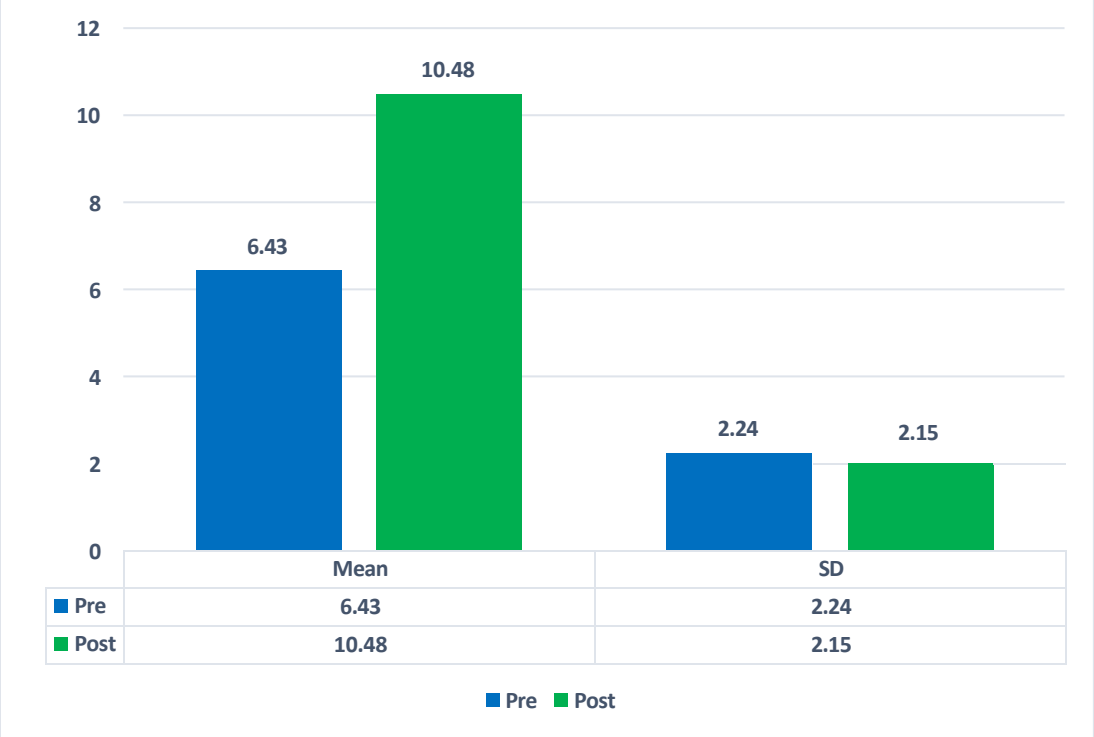
$H_0$2: There is no significant difference between the mean academic achievement scores of pre-test (BSAT-1) and post-test (BSAT-2) of the experimental group.

Table 4.4: Paired sample t-test for experimental group with respect to pre-test and post-test

Test	N	Mean	SD	Df	p-value	t-cal	t-crit	Interpretation	Decision
Pre	60	6.43	2.24	59	1.4×10^{-37}	29.82	1.67	Significant	$H_0$2 not Accepted
Post		10.48	2.15						

(Note: N= Sample, SD= Standard Deviation, Df = Degree of Freedom, p= probability value, t-cal = t-calculated, t-crit = t-critical)

Table 4.4 presents a comparison of the pre-test and post-test scores for the experimental group that received instruction through a Game Based Learning approach. The data represents a statistically significant improvement, with the mean score increasing from 6.43 (SD = 2.24) to 10.48 (SD = 2.15). The extremely low p-value (1.4×10^{-37}), well below the 0.05 significance threshold, along with the calculated t-value (29.82) exceeding the critical t-value (1.67), confirms that the difference is highly significant. Consequently, the null hypothesis ($H_0$2) is not accepted.



(Figure 4.6: Bar graph showing mean academic achievement scores of pre-test and post-test within the experimental group)

This outcome suggests that Game Based Learning had a substantial positive effect on student's performance in Biology, highlighting its effectiveness in enhancing academic achievement.

4.2.3 Hypothesis 3

$H_0$3: There is no significant difference between the mean academic achievement scores of control and experimental group in post-test (BSAT-2).

Table 4.5: Independent samples t-test for control and experimental group in Post-test; Biological Science Achievement Test (BSAT-2).

Group	N	Mean	SD	Df	p-value	t-cal	t-crit	Interpretation	Decision
Control	60	9.36	2.26	118	0.0033	2.76	1.65	Significant	$H_0$3 not Accepted
Experimental	60	10.48	2.15						

(Note: N= Sample, SD= Standard Deviation, Df = Degree of Freedom, p= probability value, t-cal = t-calculated, t-crit = t-critical)

Table 4.5 displays the findings of independent samples t-test conducted to compare the post-test performance of students in the experimental and control groups, assuming unequal variances. The control group had a mean score of 9.36 (SD = 2.26), while the experimental group achieved a higher mean of 10.48 (SD = 2.15). The calculated t-value (2.76) exceeds the critical t-value (1.65), and the p-value (0.0033) is below the 0.05 threshold. These results indicate a statistically significant difference between the mean academic achievement scores of control and experimental group in post-test (BSAT-2). Therefore, the null hypothesis ($H_0$3), is not accepted.

4.2.4 Hypothesis 4

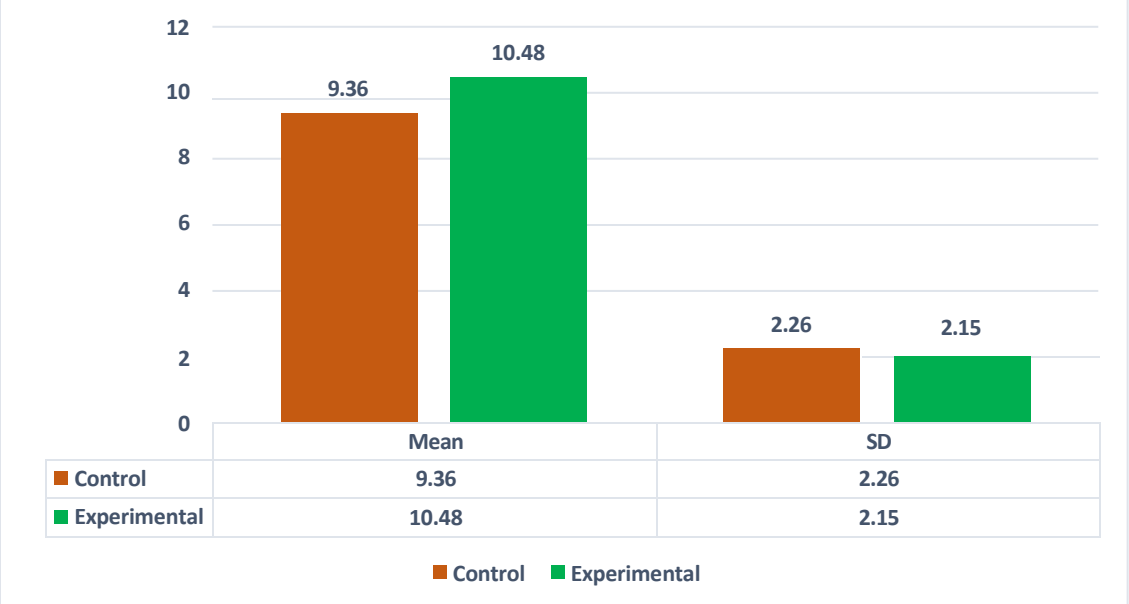
H1: There is a significant difference between the mean academic achievement scores of control and experimental group in post-test (BSAT-2).

Table 4.6: Independent Samples t-test for control and experimental group in Post-test; Biological Science Achievement Test (BSAT-2).

Group	N	Mean	SD	Df	p-value	t-cal	t-crit	Interpretation	Decision
Control	60	9.36	2.26	118	0.0033	2.76	1.65	Significant	H1 Accepted
Experimental	60	10.48	2.15						

(Note: N= Sample, SD= Standard Deviation, Df = Degree of Freedom, p= probability value, t-cal = t-calculated, t-crit = t-critical)

Table 4.6 displays the findings of independent samples t-test conducted to compare the mean academic achievement scores in post-test (BSAT-2) by the students in the experimental and control groups, assuming unequal variances. The control group had a mean score of 9.36 (SD = 2.26), while the experimental group achieved a higher mean of 10.48 (SD = 2.15). The calculated t-value (2.76) exceeds the critical t-value (1.65), and the p-value (0.0033) is below the 0.05 threshold. These results indicate a statistically significant difference between the two groups. Hence, hypothesis H1 is accepted.



(Figure 4.7: Bar graph showing significant difference between the post-test (BSAT-2) scores of the control and experimental group in the achievement test of Biology.)

This confirms that students taught through the Game Based Learning method performed significantly better than those instructed using the traditional lecture-based teaching.

4.2.5 Hypothesis 5

H2: Game Based Learning is more effective in improving student's reflective thinking level in comparison to traditional lecture method of teaching.

Table 4.7: Mean, mode and standard deviation of Control group

Reflective Thinking Level of Control Group						
			ITEM 1	ITEM 2	ITEM 3	ITEM 4.
N	Valid	60	60	60	60	60
	Missing	0	0	0	0	0
Mean			2.78	2.83	2.25	2.48
Mode			3	2	1	2
Std. Deviation			1.250	1.355	1.271	1.295

		ITEM 5	ITEM 6	ITEM 7	ITEM 8	ITEM 9
N	Valid	60	60	60	60	60
	Missing	0	0	0	0	0
Mean		2.47	2.40	3.03	2.28	2.73
Mode		1	1	2	1	2
Std. Deviation		1.420	1.355	1.438	1.303	1.376

		ITEM 10	ITEM 11	ITEM 12	ITEM 13	ITEM 14
N	Valid	60	60	60	60	60
	Missing	0	0	0	0	0
Mean		2.85	2.37	2.40	2.63	3.12
Mode		2	2	1	2	5
Std. Deviation		1.424	1.149	1.380	1.390	1.485

		ITEM 15
N	Valid	60
	Missing	0
Mean		3.07
Mode		3
Std. Deviation		1.274

Table 4.8: Mean, mode and standard deviation of Experimental group

Reflective Thinking Level of Experimental Group						
			ITEM 1	ITEM 2	ITEM 3	ITEM 4
N	Valid	60	60	60	60	60
	Missing	0	0	0	0	0
Mean			4.48	4.45	4.20	4.17
Mode			5	5	4	4
Std. Deviation			.770	.675	.798	.960

		ITEM 5	ITEM 6	ITEM 7	ITEM 8	ITEM 9
N	Valid	60	60	60	60	60
	Missing	0	0	0	0	0
Mean		4.33	4.43	4.47	4.37	4.45
Mode		4	5	5	5	5
Std. Deviation		.774	.647	.650	.802	1.048

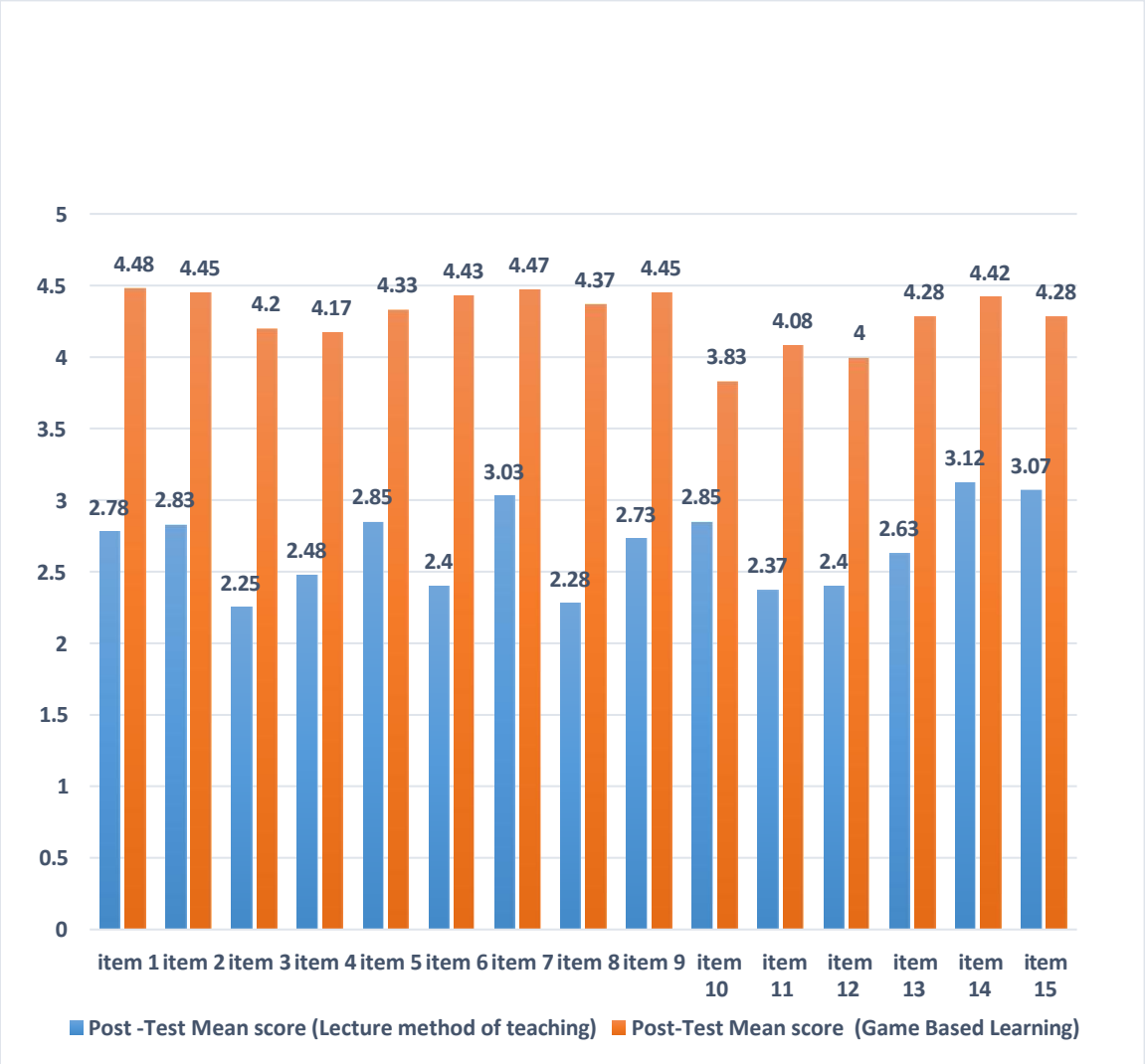
		ITEM 10	ITEM 11	ITEM 12	ITEM 13	ITEM 14
N	Valid	60	60	60	60	60
	Missing	0	0	0	0	0
Mean		3.83	4.08	4.00	4.28	4.42
Mode		4	4	4	4	5
Std. Deviation		1.317	1.078	1.074	.846	.619

		ITEM 15
N	Valid	60
	Missing	0
Mean		4.28
Mode		5
Std. Deviation		1.075

Table 4.9: Post-Intervention Item wise mean scores of Reflective Thinking level of Control group and Experimental group

Item No.	Item	Post -Test Mean score (LM)	Post-Test Mean score (GBL)	Difference
1	Analyze a problem using own experience	2.78	4.48	1.70
2	Ask questions when concept is difficult/interesting	2.83	4.45	1.62
3	Relate learned things to life	2.25	4.20	1.95
4	Improve class activities and problem-solving	2.48	4.17	1.69
5	Understand concepts by questioning friends	2.85	4.33	1.48
6	Improve answer by repeated evaluation	2.40	4.43	2.03
7	Re-think and re-examine problems in biology	3.03	4.47	1.44
8	Ask new questions while solving problems	2.28	4.37	2.09
9	Think what knowledge is needed	2.73	4.45	1.72
10	Ask what is given and needed in question	2.85	3.83	0.98
11	Express thoughts clearly and confidently	2.37	4.08	1.71
12	Criticize own success/failure	2.40	4.00	1.60
13	Guess difficulties while solving problems	2.63	4.28	1.65
14	Relate textbook to own life/world	3.12	4.42	1.30
15	Plan before starting activity	3.07	4.28	1.21

(Note: LM = Lecture Method of teaching, GBL = Game Based Learning)



(Figure 4.8: Bar graph showing comparison of mean scores of Control group and Experimental group after lecture method and Game Based Learning respectively)

From the mean comparison table, it is evident that Game-Based Learning (GBL) markedly outperforms the traditional Lecture Method across all 15 items. For instance, in Item 1 (analyzing problems using personal experience), the mean score increased from 2.78 (Lecture) to 4.48 (GBL), highlighting a significant enhancement in reflective thinking. Similarly, Item 2, which pertains to students' propensity to ask questions when concepts are challenging or intriguing, rose from 2.83 to 4.45. Items emphasizing critical thinking and self-evaluation—such as Items 6, 7, 8, and 13 consistently achieved scores above 4.2 post-GBL, compared to considerably lower scores (ranging from 2.28 to 3.03) following traditional lectures. Notably, Item 7, involving rethinking and re-examining biology problems, increased from 3.03 to 4.47.

The ability to relate learning to real-life contexts (Item 14) also improved significantly, from 3.12 to 4.42. Furthermore, communication and planning skills, assessed in Items 11 and 15, exhibited higher scores with GBL: from 2.37 to 4.08, and 3.07 to 4.28, respectively. The most substantial gains were observed in Item 8 (asking new questions while solving problems), Item 6 (improving answers through repeated evaluation), Item 3 (relating learned concepts to life), and Item 5 (understanding concepts by questioning friends), with mean score increases of 2.09, 2.03, 1.95, and 1.48, respectively.

All 15 items showed higher mean scores after Game Based Learning. GBL enhanced critical thinking, reflection, communication, and problem-solving abilities more effectively than the traditional lecture method. Mean differences ranged from about 0.98 to 2.09, favoring Game Based Learning. The data suggests that Game-Based Learning significantly enhances various aspects of reflective thinking in students, particularly in areas requiring active engagement, critical analysis, and real-world application. These findings align with existing research indicating that GBL can lead to improved learning outcomes in science education.

4.2.6 Hypothesis 6

H3: There is a positive correlation between the Game Based Learning and Reflective Thinking Level of middle stage students in Biology.

Table 4.10 Pearson Correlation (r)

	GBL Engagement Mean Score	**Reflective Thinking Level**
GBL Engagement Mean Score	1.000	.856**
Reflective Thinking Level	.856**	1.000
N	60	60
Sig. (2-tailed)	—	.000

***(Note: .01 level (2-tailed)** significance is indicated by **.856** (**) correlation. This shows a **strong positive correlation** between GBL Engagement and Reflective Thinking Level, statistically significant at the 0.01 level.)*

The analysis of the relationship between students' engagement in game-based learning (GBL) and their reflective thinking levels reveals a strong positive correlation. The Pearson correlation coefficient of r = 0.856 indicates a very strong positive correlation between GBL engagement and higher level of reflective thinking. This suggests that students who reported higher levels of engagement during GBL activities also tend to demonstrate higher levels of reflective thinking afterward.

The strength of this relationship implies that GBL may not only enhance immediate learning engagement but also contribute significantly to fostering deeper cognitive processes such as reflection. In practical terms, this result supports the pedagogical value of integrating GBL into instructional design for middle stage learners. It emphasizes the potential of GBL to stimulate active involvement and critical self-reflection, both of which are essential for meaningful and lasting learning. Moreover, the consistently high mean scores across both variables (most values ranging between 4.0 and 4.6) reinforce the overall effectiveness of GBL strategies in promoting both engagement and reflective capacity.

4.3 Analyzing perception towards GBL

The responses from the Experimental group to assess their perceptions of a game-based learning tool was rated on a 5-point scale:(1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree).

4.3.1 Theme wise analysis

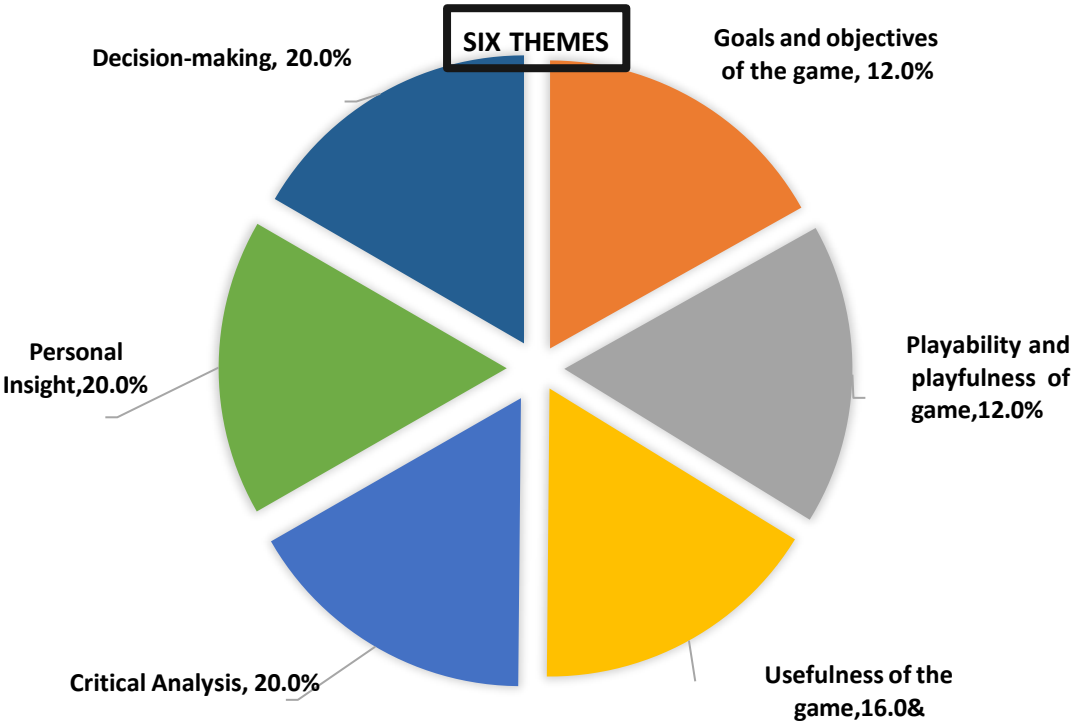
The tool was divided into six themes. Thus, theme wise analysis occurred.

'Goals & Objectives of the Game' theme explores whether the game stimulates higher-order thinking, promotes peer collaboration, and strengthens knowledge recall. 'Playability & Playfulness' theme focused on the game's mechanics and enjoyment. 'Usefulness of the Game' theme evaluates the game's perceived value and its capacity to foster depth and relationships. 'Critical Analysis' aims to assess metacognitive and reflective learning. 'Personal Insight' theme focuses on self-awareness and growth. 'Decision-Making' theme gauges strategic thinking and transferability. These items evaluate critical choice-making skills and how students adapt and apply strategies beyond the game.

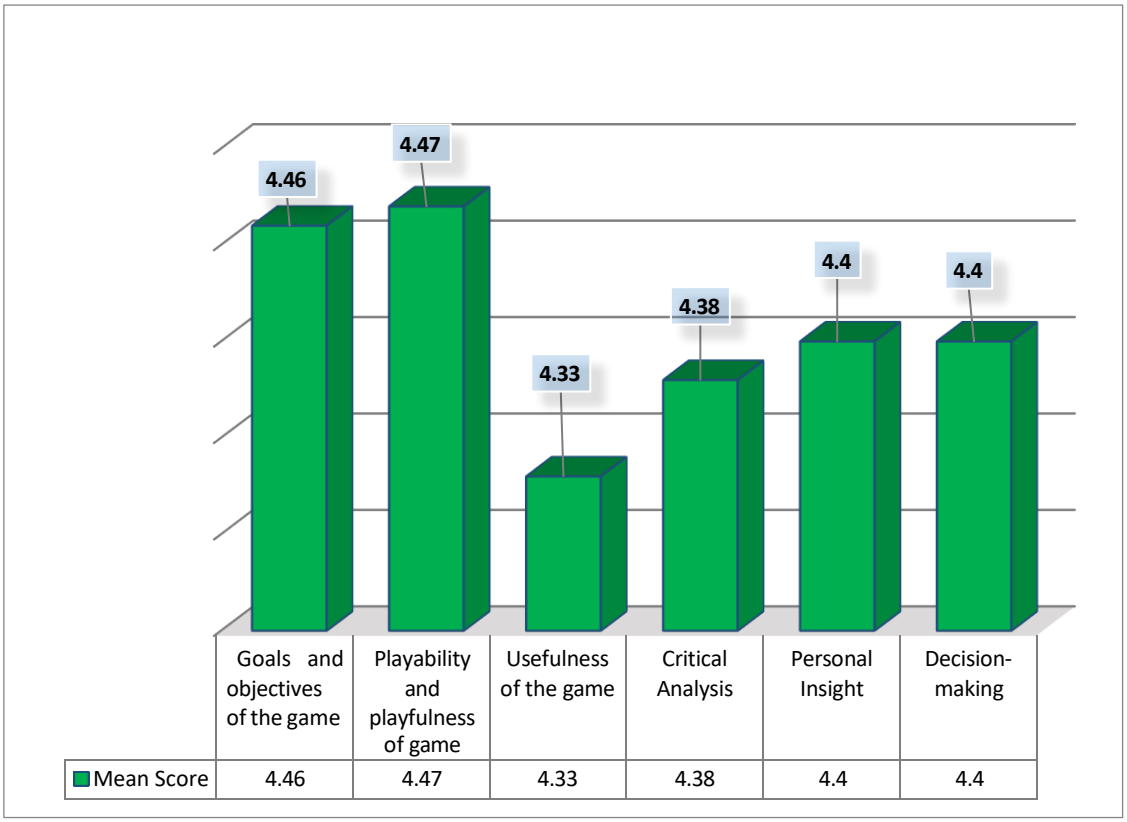
Table 4.11: Theme wise mean scores along with contribution percentage

Theme	Mean Score	Item No.	Contribution (%)
Goals and objectives of the game	4.46	Item1, Item2 and Item3	12.0%
Playability and playfulness of game	4.47	Item4, Item5 and Item6	12.0%
Usefulness of the game	4.33	Item7, Item8, Item9, Item10	16.0%
Critical Analysis	4.38	Item11, Item12, Item13, Item14 and Item15	20.0%
Personal Insight	4.40	Item16, Item17, Item18, Item19 and Item20	20.0%
Decision-making	4.40	Item21, Item22, Item23, Item24 and Item25	20.0%

The analysis across 25 items categorized under six themes reveals consistently high mean scores, ranging from 4.33 to 4.47 on a 5-point scale. The theme **"Playability and Playfulness"** recorded the highest mean score (4.47), indicating strong agreement that the game was enjoyable, fair, and engaging. **"Goals and Objectives of the Game"** followed closely with a score of 4.46, showing that learners found the game meaningful and helpful in recalling biology concepts. The **"Decision-Making"** and **"Personal Insight"** themes both scored 4.40, suggesting that the game effectively promoted reflection, strategic thinking, and self-awareness in learning. **"Critical Analysis"** also showed a strong impact with a mean of 4.38, highlighting that students developed better conceptual understanding and evaluative skills through gameplay. Although **"Usefulness of the Game"** scored slightly lower at 4.33, it still indicates a positive response regarding the game's ability to promote deeper subject engagement and social interaction. In terms of contribution, the themes of Critical Analysis, Personal Insight, and Decision-Making each contributed 20%, comprising the core of the learning experience.



(Figure 4.9: Pie chart representing theme wise percentage contribution towards CARD-CONNECT REFLECT)



(Figure 4.10: Bar graph representing theme wise mean score towards CARD-CONNECT REFLECT)

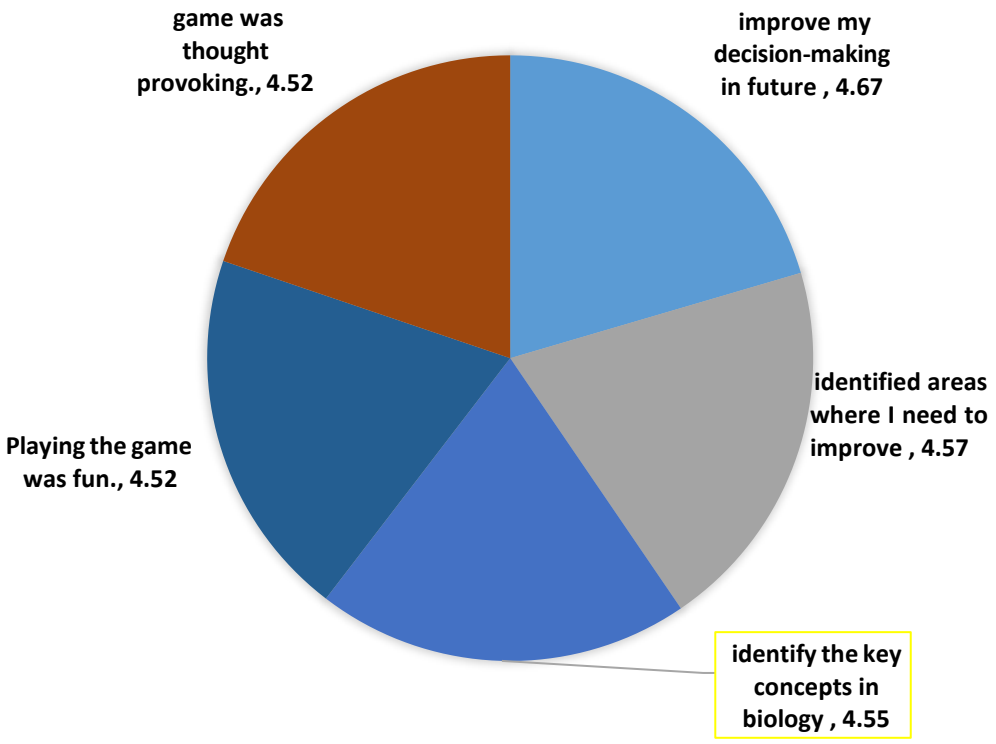
Overall, the findings reflect that the game was perceived as an effective, enjoyable, and cognitively stimulating tool for Biology education at the middle stage. These mean scores indicate a consistently positive perception across all six themes, with the highest ratings in Playability and Fairness and Goals and Objectives of the Game.

4.3.2 Item wise analysis

average scores were calculated using weighted means. The highest and lowest rated statements are summarized below:

Table 4.12 Items with Strong Perceptions towards CARD-CONNECT REFLECT

Item No.	Statement	Mean Score	Item wise contributed Percentage (%)
25	I think about how I could improve my decision-making in future and apply the decision-making strategies from the game to other subjects.	4.67	20.52
17	I have identified areas where I need to improve after playing the game.	4.57	20.08
11	I can identify the key concepts in biology I learned from the game-based activities.	4.55	20
6	Playing the game was fun.	4.52	19.84
1	The game was thought provoking.	4.52	19.84



(Figure 4.11: Pie chart representing the top 5 perceptions towards CARD-CONNECT REFLECT)

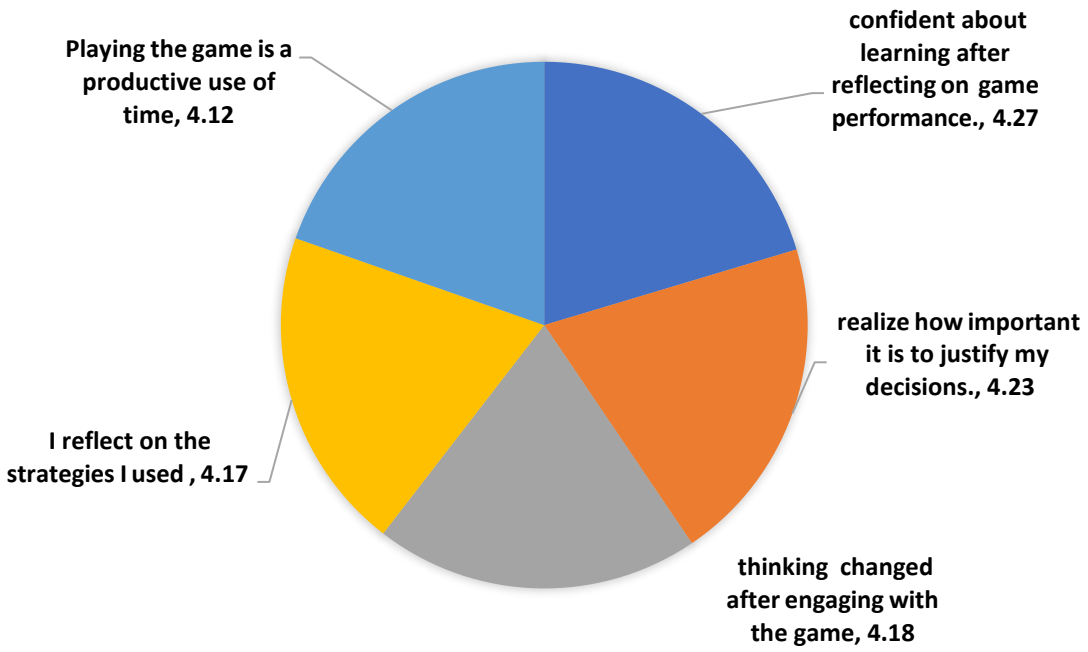
Table 4.13 Items with Moderate Perceptions towards CARD-CONNECT REFLECT

Item No.	Statement	Mean Score	Item wise contributed Percentage (%)
18	Understanding strengths/weaknesses in Biology	4.51	6.79
3	Helps with recall of concepts/terms	4.50	6.77
5	Game rules provide fair play	4.50	6.77
22	Understand how choices affected outcomes	4.47	6.73
2	Game encouraged student interaction	4.47	6.73
21	Consider multiple perspectives	4.43	6.67
12	Game challenges helped problem-solving in Biology	4.43	6.67
20	Helped thoughtful decisions in Biology	4.43	6.67

Item No.	Statement	Mean Score	Item wise contributed Percentage (%)
10	Would recommend the game to friends	4.42	6.65
15	Recognize and correct mistakes	4.40	6.62
14	Feedback helped evaluate understanding	4.40	6.62
4	Game promotes healthy competition/cooperation	4.38	6.59
9	Helped build better relationships	4.38	6.59
13	Understand reasoning behind decisions	4.37	6.58
7	Encouraged deeper exploration of subject matter	4.37	6.58

Table 4.14 Items with Lowest Perceptions towards CARD-CONNECT REFLECT

Item No.	Statement	Mean Score	Item wise contributed Percentage (%)
16	I feel more confident about my learning after reflecting on my game performance.	4.27	20.36
23	Playing the game made me realize how important it is to justify my decisions.	4.23	20.17
19	I can see how my thinking has changed after engaging with the game	4.18	19.93
24	I reflect on whether the strategies I used in the game were effective or not and try to make better choices.	4.17	19.89
8	Playing the game is a productive use of time	4.12	19.65



(Figure 4.12: Pie chart representing the lowest 5 perceptions towards the CARD-CONNECT REFLECT)

The pie chart indicates relatively lower agreement with statements about self-reflection, peer recommendation, and interactive aspects of the game. Even the lowest-ranked items received mean scores above 4.0, suggesting overall positive acceptance but slightly lower agreement on metacognitive outcomes like deep reflection and strategic reasoning.

The analysis reveals **a strong positive perception** of the developed game among students, particularly in the areas of concept understanding, motivation, and decision-making. The game appears to be an effective pedagogical tool in middle school biology education, aligning with 21st-century skills and promoting engagement, critical thinking, and self-assessment.