# CHAPTER 3 : RESEARCH METHODOLOGY

The present chapter provides an overview of the study's research methodology, wherein the design of the study, the population, the sample, the sampling technique, data collection instruments, pilot study of data collection instruments, data collection procedure, and data analysis techniques are all described.

## 3.1 Research method adopted

The present study employs a descriptive survey methodology to collect data from a substantial number of cases at a specific point in time in order to describe and interpret "what is" at present. The focus is on the statistics that emerge when data are extracted from a number of individual cases, rather than on the characteristics of individuals as a whole (Best & Kahn, 2006). Furthermore, the present study employed a correlational research design, a method that facilitates the determination of relationships between dependent and independent variables and assesses the predictive power of the independent variables (Creswell, 2012). The study's dependent variable was the academic achievement of students in the subject of Biology. Based on correlational research, the impact of brain hemispheric dominance, metacognitive awareness, and perceptual learning style preferences on students' academic achievement was investigated as part of the study's scope.

## 3.2 Area of the study

The area of study is the state of Sikkim comprising of the Mangan, Gangtok, Namchi, Gyalshing, Soreng and Pakyong districts. In terms of area, it is a little larger than Goa, which is the smallest state in India, making it the second smallest state. However, in terms of population, Sikkim is the least populous in India with a total population of approximately 6.11 lakhs (Census, 2011).


*Figure 3.1 Area of Study*

*Source: https://www.toptourguide.com/toptour-indiamap.htm*

### 3.3 Population of the study

The population for the study includes all the senior secondary students from various government and private schools in Sikkim who have taken up the science stream, specifically biological sciences and studying Biology as one of the major subjects.

### 3.4 Sample and Sampling technique

In quantitative research, a good sample is one that accurately represents the population from which it was drawn (Gay & Mills, 2019). The exact number of senior secondary school students taking biological sciences in Class XII could not be predetermined because there were no such records available, but the total number of schools having the Science stream at the senior secondary level in the state could be identified.

Since Sikkim is a small state, choosing districts would further reduce the population. Therefore, schools from the entire state as a whole, without specifically selecting the districts, have been included in the study. There are only a countable number of schools that offer Science stream at the senior secondary level. Also, because of the state's hilly topography and varied terrain, the distribution of schools in the districts are inconsistent, some have very less number of schools while some have many schools, which is why selecting a few districts at random would not be suitable. Also, selecting only a few districts purposively would lead to non-probability sampling, which would further impede the generalizability of the results. Hence, cluster sampling was used taking the state as a whole.

According to Gay & Mills (2019), cluster sampling may be the only feasible method of selecting a representative sample when the researcher is unable to obtain the sampling frame.

Hence, taking each school as a cluster, cluster sampling was used as follows:

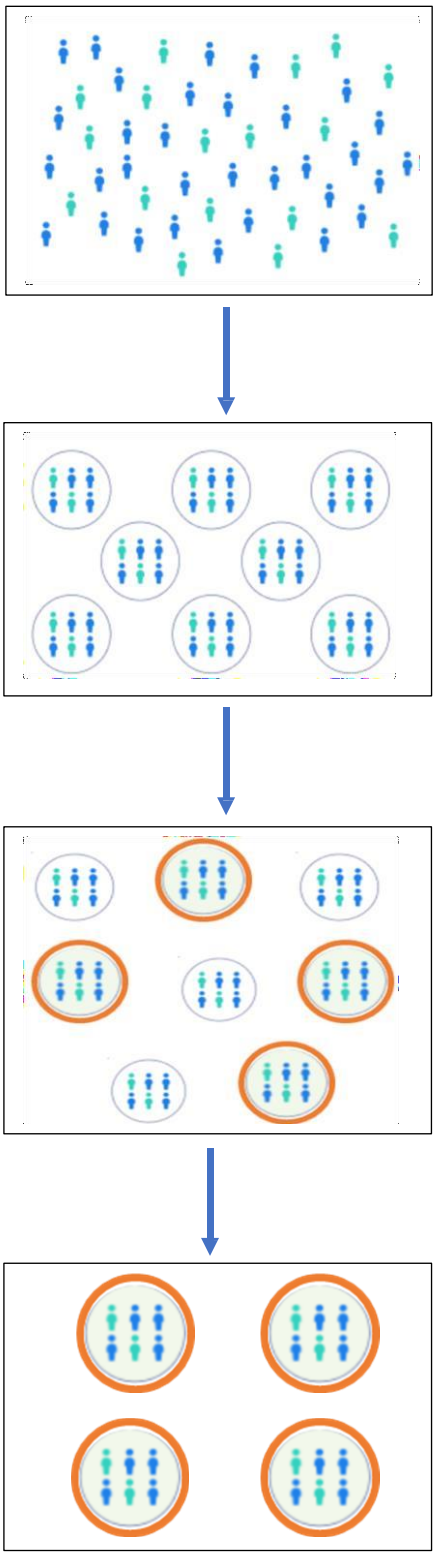
It was found that there are 72 schools in Sikkim having Science stream at the higher secondary level out of which 18 are private and 54 are government schools.

50 percent of the schools were selected randomly for the study, i.e., 9 (out of 18) private schools and 27 (out of 54) government schools. Hence, 36 schools were randomly selected using lottery method (without replacement) to ensure adequate representation of the population. All students of the selected schools comprised the sample for the study.

In doing so, a total of 640 students encompassed the subjects for the study.

However, due to incomplete filling up of questionnaires by 5 students, only 635 questionnaires could be utilized for analysis. The final sample size consisted of 635 school students.

The diagrammatic representations of determination of sample size are shown in the following pages.



Population= All senior secondary school students of Class 12 studying Biology as a major subject

72 schools (clusters) identified

36 schools (clusters) randomly selected

Data collected from all randomly selected schools (clusters)

*Figure 3.2 Diagrammatic representation of determination of sample size*

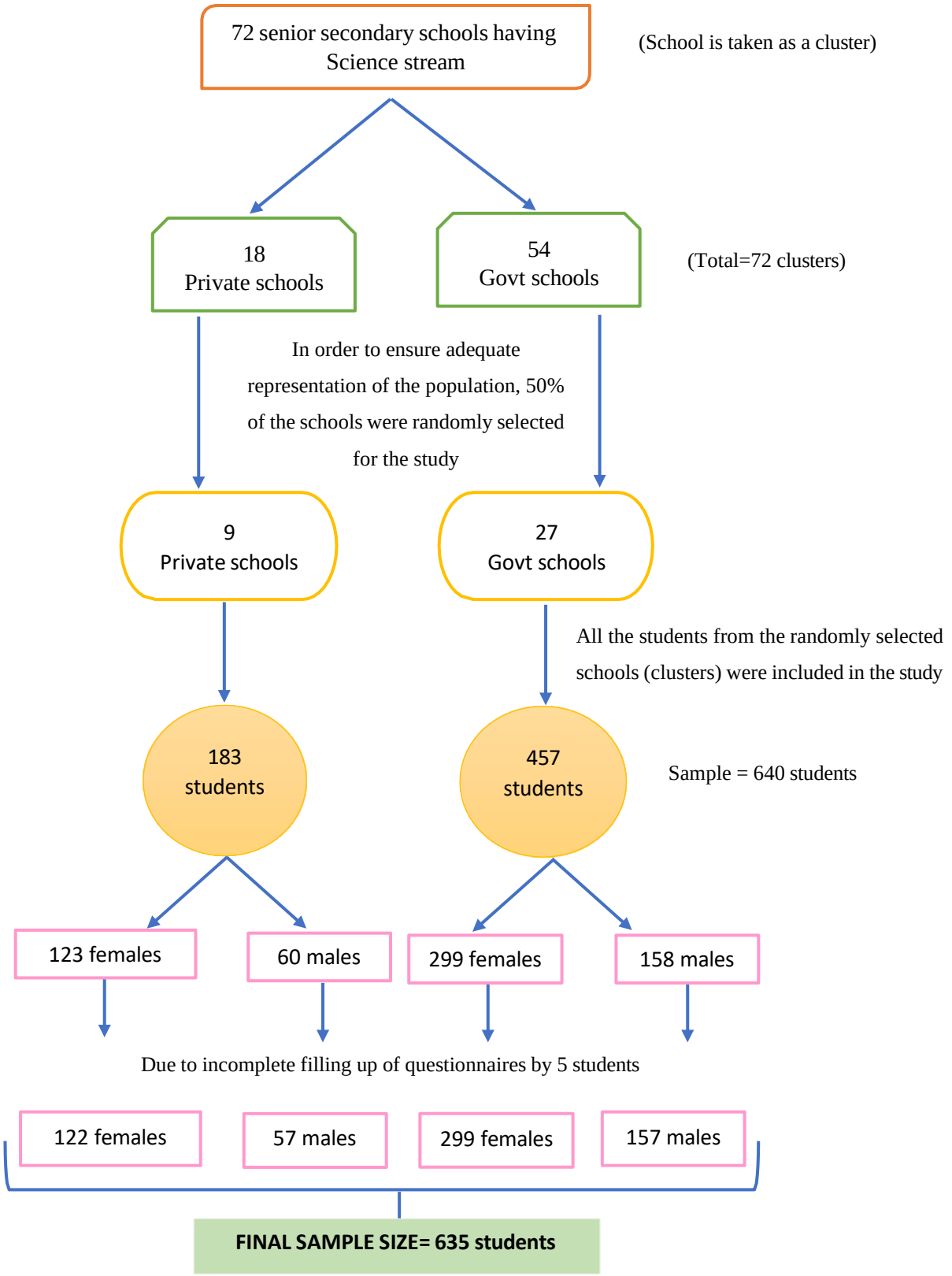



*Figure 3.3 Flowchart showing stages for determination of sample size*

*Table 3.1 School Wise Distribution of the final sample for the study*

| SL. NO. | NAME OF THE SCHOOL | TYPE OF SCHOOL | NO. OF STUDENTS | | |
|---|---|---|---|---|---|
| | | | **Males** | **Females** | **Total** |
| **1.** | Tadong Govt. SSS | Government | 6 | 12 | 18 |
| **2.** | Deorali Govt. SSS | Government | 0 | 37 | 37 |
| **3.** | West point Govt. SSS | Government | 3 | 8 | 11 |
| **4.** | Baha'i SSS, Tadong | Private | 3 | 5 | 8 |
| **5.** | Tashi Namgyal Academy | Private | 9 | 15 | 24 |
| **6.** | Enchey Govt. SSS | Government | 3 | 13 | 16 |
| **7.** | Tashi Namgyal Govt. SSS | Government | 36 | 0 | 36 |
| **8.** | Paljor Namgyal Girls SSS | Private | 0 | 41 | 41 |
| **9.** | Greendale School | Private | 2 | 5 | 7 |
| **10.** | Rangpo Govt. SSS | Government | 8 | 12 | 20 |
| **11.** | Singtam Govt. SSS | Government | 9 | 12 | 21 |
| **12.** | Holy Cross School | Private | 17 | 23 | 40 |
| **13.** | Namchi Govt. Girls SSS | Government | 0 | 14 | 14 |
| **14.** | Jorethang Govt. SSS | Government | 4 | 3 | 7 |
| **15.** | Namchi Public School | Private | 6 | 11 | 17 |
| **16.** | Victoria Cross Ganju Lama Govt. SSS | Government | 14 | 12 | 26 |
| **17.** | St. Xavier's School | Private | 10 | 12 | 22 |
| **18.** | Rumtek Govt. SSS | Government | 7 | 11 | 18 |
| **19.** | Baha'i SSS, Saramsa | Private | 5 | 4 | 9 |
| **20.** | Ranipool Govt. SSS | Government | 5 | 19 | 24 |
| **21.** | Burtuk Govt. SSS | Government | 2 | 3 | 5 |
| **22.** | Pelling Govt. SSS | Government | 6 | 9 | 15 |
| **23.** | Kyongsha Govt. Girls SSS | Government | 0 | 16 | 16 |
| **24.** | Darap Govt. SSS | Government | 2 | 7 | 9 |
| **25.** | Dentam Govt. SSS | Government | 7 | 9 | 16 |
| **26.** | Hee Yangthang Govt. SSS | Government | 3 | 11 | 14 |
| **27.** | Bermiok Martam Govt. SSS | Government | 2 | 10 | 12 |
| **28.** | Sreebadam Govt. SSS | Government | 2 | 10 | 12 |
| **29.** | Kaluk Govt. SSS | Government | 5 | 11 | 16 |
| **30.** | Chakhung Govt. SSS | Government | 6 | 10 | 16 |
| **31.** | Don Bosco School | Private | 5 | 5 | 10 |
| **32.** | Sombaria Govt. SSS | Government | 5 | 17 | 22 |
| **33.** | Tharpu Govt. SSS | Government | 5 | 10 | 15 |
| **34.** | Assam Lingzey Govt. SSS | Government | 7 | 9 | 16 |
| **35.** | Soreng Govt. SSS | Government | 7 | 11 | 18 |
| **36.** | Mangan Govt. SSS | Government | 3 | 4 | 7 |
| | **TOTAL** | | **214** | **421** | **635** |

*Table 3.2 Distribution of Sample with Respect to gender and type of school*

| | | No. of students | Total |
|---|---|---|---|
| **Type of school** | *Private* | 179 | **635** |
| | *Government* | 456 | |
| **Gender** | *Males* | 214 | **635** |
| | *Females* | 421 | |

## 3.5 Research Instruments

### 3.5.1 Brain Dominance Inventory (BDI)

The Brain Dominance Inventory (BDI) was employed to study the participants' brain hemispheric dominance. This 39-item questionnaire has three multiple choice alternatives (a, b, c) for each item. This questionnaire helps classify them into left brainers, right brainers or whole brainers. In order to group participants into these three categories, first, the values of "a", "b" and "c" items in the questionnaire were counted separately. Next, the sum of all "a" scores were subtracted from the sum of "b" scores. Finally, in cases where "c" values were 17 or greater, the "b" minus "a" scores were divided by three, and rounded up to the nearest number. In cases where "c" values were between 10 and 16, the "b" minus "a" scores were divided by two, and rounded up to the nearest number. Ultimately, the participants who received scores less than zero were categorized in the left-brain dominant group. Those with scores were greater than zero were considered to be right brain dominant, and those who scored zero were classified as whole brainers.

#### *3.5.1.1 Internal consistency of the BDI*

*Table 3.3 Internal consistency reliability of the BDI*

| Cronbach's Alpha | No. of items |
|---|---|
| 0.725 | 39 |

Internal consistency reliability (Gay & Mills, 2019) refers to "the degree to which items in a test are consistent with one another and with the entire test as a whole" (Gay & Mills, 2019). The internal consistency of the items as calculated by the Cronbach's alpha coefficient is 0.725, which is good and acceptable. A recent study by Arabmofrad et al. (2021) found its reliability to be 0.76.

#### *3.5.1.2 Test-Retest reliability*

Test-Retest reliability or test of stability, is the "degree to which scores on the same test are consistent over time. In other words, this type of reliability provides evidence that scores obtained on a test at one time (test) are the same or close to the same when the test is readministered some other time (retest). The more similar the scores on the test over time, the more stable the test scores" (Gay & Mills, 2019).

The Brain dominance inventory was administered on the same group of students (N=200) twice at an interval of 3 weeks between the test and the retest. The stability coefficient obtained was 0.81, which indicates high reliability.

### 3.5.2 Metacognitive awareness inventory

The Metacognitive awareness inventory developed by Schraw and Dennison (1994) was employed to ascertain the level of metacognitive awareness. The questionnaire has 52 items in 2 dimensions- Metacognitive knowledge and Metacognitive regulation, comprising of 3 and 5 subdimensions respectively. The 3 subdimensions for Metacognitive knowledge include Declarative knowledge (8 items), Procedural knowledge (4 items) and Conditional knowledge (5 items) while the 5 subdimensions for Metacognitive regulation include Planning (7 items), Information management (9 items), Debugging (5 items), Monitoring (8 items) and Evaluation (6 items). The statements are scored either as 1 or 0. A total score for metacognitive awareness is obtained by adding the scores of all 52 items. For each metacognitive dimension, the scores on the dimensions are totalled.

*Table 3.4 Z-score norms for the MAI*

| Raw scores | Z-scores |
|---|---|
| 52 | 1.65802 |
| 51 | 1.57752 |
| 50 | 1.49701 |
| 49 | 1.41651 |
| 48 | 1.33600 |
| 47 | 1.25550 |
| 46 | 1.17499 |
| 45 | 1.09449 |
| 44 | 1.01398 |
| 43 | .93348 |
| 42 | .85297 |
| 41 | .77247 |
| 40 | .69196 |
| 39 | .61146 |

| | |
|---|---|
| 38 | .53095 |
| 37 | .45045 |
| 36 | .36994 |
| 35 | .28943 |
| 34 | .20893 |
| 33 | .12842 |
| 32 | .04792 |
| 31 | -.03259 |
| 30 | -.11309 |
| 29 | -.19360 |
| 28 | -.27410 |
| 27 | -.35461 |
| 26 | -.43511 |
| 25 | -.51562 |
| 24 | -.59612 |
| 23 | -.67663 |
| 22 | -.75713 |
| 21 | -.83764 |
| 20 | -.91814 |
| 19 | -.99865 |
| 18 | -1.07915 |
| 17 | -1.15966 |
| 16 | -1.24016 |
| 15 | -1.32067 |
| 13 | -1.48168 |
| 12 | -1.56218 |
| 11 | -1.64269 |
| 10 | -1.72319 |

*Table 3.5 Norms for interpretation of Z-Score for the MAI*

| | **z-scores** | **Raw scores** |
|---|---|---|
| Very high | +1.26 and above | 48 and above |
| High | +0.51 to +1.25 | 38-47 |
| Average | -0.50 to +0.50 | 25-37 |
| Low | -0.51 to -1.25 | 15-24 |
| Very low | -1.26 and below | 14 and below |

### *3.5.2.1 Internal consistency of the MAI*

*Table 3.6 Internal consistency of the total MAI*

| Cronbach's Alpha | No. of items |
|---|---|
| 0.815 | 52 |

*Table 3.7 Item-Total Statistics of the MAI*

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| Item1 | 39.5095 | 45.214 | .215 | .813 |

| | | | | |
|---|---|---|---|---|
| Item2 | 39.5931 | 44.690 | .272 | .811 |
| Item3 | 39.6562 | 44.839 | .230 | .813 |
| Item4 | 39.6057 | 45.023 | .212 | .813 |
| Item5 | 39.6009 | 44.919 | .231 | .812 |
| Item6 | 39.5000 | 44.648 | .330 | .810 |
| Item7 | 39.5678 | 45.333 | .171 | .814 |
| Item8 | 39.6325 | 43.490 | .320 | .810 |
| Item9 | 39.4101 | 45.765 | .167 | .814 |
| Item10 | 39.4826 | 45.280 | .218 | .813 |
| Item11 | 39.5978 | 44.797 | .252 | .812 |
| Item12 | 39.6151 | 44.822 | .243 | .812 |
| Item13 | 39.4763 | 44.834 | .313 | .811 |
| Item14 | 39.4700 | 44.821 | .204 | .814 |
| Item15 | 39.5615 | 44.942 | .241 | .812 |
| Item16 | 39.4416 | 45.672 | .163 | .814 |
| Item17 | 39.5284 | 45.194 | .210 | .813 |
| Item18 | 39.6104 | 44.718 | .261 | .812 |
| Item19 | 39.5915 | 44.416 | .319 | .810 |
| Item20 | 39.6120 | 44.247 | .339 | .809 |
| Item21 | 39.5126 | 44.822 | .288 | .811 |
| Item22 | 39.4401 | 45.482 | .207 | .813 |
| Item23 | 39.5505 | 44.956 | .243 | .812 |
| Item24 | 39.4795 | 45.460 | .184 | .813 |
| Item25 | 39.4243 | 45.875 | .129 | .814 |
| Item26 | 39.4527 | 45.806 | .127 | .815 |
| Item27 | 39.5473 | 44.624 | .304 | .811 |
| Item28 | 39.6309 | 43.990 | .375 | .808 |
| Item29 | 39.5568 | 45.170 | .203 | .813 |
| Item30 | 39.4700 | 45.204 | .242 | .812 |
| Item31 | 39.5126 | 44.986 | .257 | .812 |
| Item32 | 39.6215 | 44.849 | .237 | .812 |
| Item33 | 39.7366 | 44.122 | .329 | .810 |
| Item34 | 39.5773 | 44.592 | .295 | .811 |
| Item35 | 39.6767 | 44.140 | .337 | .809 |
| Item36 | 39.5095 | 44.490 | .353 | .809 |
| Item37 | 39.6073 | 44.918 | .229 | .813 |
| Item38 | 39.6404 | 43.434 | .326 | .810 |

| | | | | |
|---|---|---|---|---|
| Item39 | 39.4022 | 45.631 | .209 | .813 |
| Item40 | 39.4858 | 45.211 | .230 | .812 |
| Item41 | 39.5631 | 45.039 | .223 | .813 |
| Item42 | 39.5237 | 45.138 | .223 | .813 |
| Item43 | 39.4905 | 44.889 | .290 | .811 |
| Item44 | 39.4353 | 44.907 | .204 | .813 |
| Item45 | 39.6057 | 44.340 | .326 | .810 |
| Item46 | 39.3486 | 46.098 | .153 | .814 |
| Item47 | 39.4543 | 45.323 | .230 | .812 |
| Item48 | 39.6215 | 44.703 | .260 | .812 |
| Item49 | 39.5268 | 44.240 | .387 | .808 |
| Item50 | 39.5726 | 44.147 | .375 | .809 |
| Item51 | 39.4558 | 45.534 | .183 | .813 |
| Item52 | 39.3517 | 46.083 | .151 | .814 |

The internal consistency of the items as calculated by the Cronbach's alpha coefficient is 0.815, which is very good.

*Table 3.8 Internal consistency reliability for Dimension 1: Metacognitive knowledge*

| Cronbach's Alpha | No. of items |
|---|---|
| 0.853 | 17 |

*Table 3.9 Internal consistency reliability for Dimension 2: Metacognitive regulation*

| Cronbach's Alpha | No. of items |
|---|---|
| 0.812 | 35 |

#### *3.5.2.2 Test-Retest reliability*

The Metacognitive awareness inventory was administered on the same group of students (N=200) twice at an interval of 3 weeks. The reliability coefficient obtained was found to be 0.85, which indicates high reliability.

### 3.5.3 Perceptual learning style preference scale for Biology students

The Perceptual learning style preference scale is a questionnaire developed by the investigator specifically for this study. The responses are collected on a 5-point Likert scale (Strongly disagree, Disagree, Neither agree nor disagree, Agree and Strongly

agree). The following steps are involved in preparing the preliminary draft of the scale to its final draft, right up to the establishment of its validity and reliability:

#### *3.5.3.1 Preparation of first draft of the scale*

After identifying the dimensions of the scale on the basis of relevant literature reviewed, three dimensions were recognized: Preference for Visual learning (V), Preference for Auditory learning (A) and Preference for Kinesthetic learning (K), collectively known as VAK. The investigator prepared the preliminary draft of the Perceptual learning style preference scale for Biology students (PLSP-B) comprising of 48 items.

#### *3.5.3.2 Face validity and Content validity of the scale*

According to Gay & Mills (2019), face validity refers to "the degree to which a test appears to measure what it claims to measure." Anastasia (1958) also states that "the face validity refers not to what the test necessarily measures but to what it appears to measure." Content validity is the degree to which a test measures an intended content area (Gay & Mills, 2019).

To establish its face validity and content validity, the scale was given to subject experts to:

• Examine the items critically for language and content;

• Clarify any ambiguities;

• Verify that the items accurately reflect the dimensions for which they have been developed;

• Make the required modifications in accordance with the feedback provided by the experts.

#### *3.5.3.3 Preparation of final draft of the scale*

After receiving the feedback and evaluation reports from experts, fourteen items were modified, none were deleted.

The norms of reference were also developed for the interpretation of the test scores as follows:

- The lowest score for the given tool is 10 and the highest is 50. Hence, the raw scores from 10 to 50 were first converted to z scores.

*Table 3.10 Z-score norms for the PLSPS*

| Raw scores for every dimension | Z-scores |
|---|---|
| 10 | -1.66957 |
| 11 | -1.58609 |
| 12 | -1.50261 |
| 13 | -1.41913 |
| 14 | -1.33565 |
| 15 | -1.25218 |
| 16 | -1.16870 |
| 17 | -1.08522 |
| 18 | -1.00174 |
| 19 | -.91826 |
| 20 | -.83478 |
| 21 | -.75131 |
| 22 | -.66783 |
| 23 | -.58435 |
| 24 | -.50087 |
| 25 | -.41739 |
| 26 | -.33391 |
| 27 | -.25044 |
| 28 | -.16696 |
| 29 | -.08348 |
| 30 | .00000 |
| 31 | .08348 |
| 32 | .16696 |
| 33 | .25044 |
| 34 | .33391 |
| 35 | .41739 |
| 36 | .50087 |
| 37 | .58435 |
| 38 | .66783 |
| 39 | .75131 |
| 40 | .83478 |
| 41 | .91826 |
| 42 | 1.00174 |
| 43 | 1.08522 |
| 44 | 1.16870 |
| 45 | 1.25218 |
| 46 | 1.33565 |
| 47 | 1.41913 |
| 48 | 1.50261 |
| 49 | 1.58609 |
| 50 | 1.66957 |

*Table 3.11 Norms for Interpretation of Z-Scores for the PLSPS*

| | Range of raw scores |
|---|---|
| Major preference | 42-50 |
| Minor preference | 19-41 |
| Negligible | 10-18 |

### *3.5.3.4 First pilot testing*

The pilot testing was carried out in two phases:

In the first phase, the scale was pilot tested on 20 students to determine whether the items are meaningful to the target group and legible by them, whether the sentence structures are understood, and whether any of the items need to be further simplified. The researcher additionally engaged with the students in order to gain a deeper understanding of the items' representativeness and the language used in the research. A few statements had to be simplified.

In the second phase, the scale was administered to 200 students to establish the reliability of the scale.

### *3.5.3.5 Internal consistency of the PLSPS*

*Table 3.12 Internal consistency for Visual learning (V)*

| Cronbach's Alpha | No. of items |
|---|---|
| 0.837 | 10 |

*Table 3.13 Item-Total Statistics of Visual learning (V)*

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| Item1 | 55.3250 | 56.071 | .480 | .826 |
| Item2 | 55.1000 | 56.810 | .629 | .820 |
| Item3 | 55.2750 | 58.666 | .486 | .827 |
| Item4 | 55.3000 | 60.267 | .376 | .832 |
| Item5 | 55.5500 | 55.946 | .573 | .821 |
| Item6 | 55.7750 | 59.512 | .274 | .839 |
| Item7 | 55.8000 | 58.985 | .393 | .831 |
| Item8 | 55.6500 | 55.156 | .665 | .816 |
| Item9 | 55.6500 | 56.900 | .428 | .830 |
| Item10 | 55.4750 | 53.640 | .642 | .816 |

*Table 3.14 Internal consistency for Auditory learning (A)*

| Cronbach's Alpha | No. of items |
|---|---|
| 0.833 | 10 |

*Table 3.15 Item-Total Statistics of Auditory learning (A)*

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| Item1 | 50.0750 | 53.456 | .466 | .822 |
| Item2 | 50.1750 | 55.789 | .511 | .820 |
| Item3 | 50.2750 | 56.563 | .361 | .828 |
| Item4 | 49.7000 | 59.908 | .138 | .840 |
| Item5 | 49.0000 | 55.231 | .656 | .815 |
| Item6 | 49.7500 | 56.551 | .353 | .829 |
| Item7 | 49.7500 | 55.167 | .511 | .820 |
| Item8 | 49.2000 | 57.549 | .414 | .825 |
| Item9 | 49.5000 | 55.231 | .559 | .818 |
| Item10 | 49.6250 | 59.471 | .216 | .834 |

*Table 3.16 Internal consistency for Kinaesthetic learning (K)*

| Cronbach's Alpha | No. of items |
|---|---|
| 0.806 | 10 |

*Table 3.17 Item-Total Statistics of Kinaesthetic learning (K)*

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|---|---|---|---|---|
| Item1 | 53.4250 | 59.379 | .472 | .853 |
| Item2 | 53.0000 | 60.513 | .506 | .852 |
| Item3 | 52.8500 | 61.772 | .574 | .852 |
| Item4 | 53.1500 | 61.721 | .393 | .856 |
| Item5 | 53.5250 | 57.333 | .536 | .850 |
| Item6 | 53.2750 | 59.589 | .556 | .850 |
| Item7 | 53.6000 | 59.528 | .394 | .858 |
| Item8 | 53.5750 | 63.789 | .139 | .869 |
| Item9 | 53.8500 | 61.259 | .341 | .859 |
| Item10 | 53.5500 | 62.203 | .267 | .863 |

#### *3.5.3.6 Test-Retest reliability*

The degree of consistency in test scores over time is known as test-retest reliability, or test of stability (Gay & Mills, 2019).

The Perceptual learning style preference scale was administered on the same group of students (N=200) twice at an interval of 3 weeks between the test and the retest. The

stability coefficients for the three dimensions were 0.87, 0.89 and 0.86 respectively, indicating high reliability.

### *3.5.3.7 Exploratory Factor Analysis*

An Exploratory factor analysis was also conducted to check if the dimensions for Metacognitive awareness and Perceptual learning style preferences load into their respective constructs.

*Table 3.18 KMO and Bartlett's Test*

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .620 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 589.665 |
| | Df | 10 |
| | Sig. | .000 |

A Kaiser-Meyer-Olkin value of 0.62 shows that the sample used for the piloting (N=200) is adequate, which is highly significant at the 0.01 level of significance.

*Table 3.19 Principal Axis Factoring with Promax Rotation for MA and PLSPS dimensions*

| **Structure Matrix** | | | |
|---|---|---|---|
| | Factor | | |
| | Perceptual Learning Style Preferences | Metacognitive Awareness | |
| Visual Learning | .685 | | 0.702422 |
| Auditory Learning | .576 | | |
| Kinesthetic Learning | .741 | | |
| Metacognitive knowledge | | .743 | 0.669901 |
| Metacognitive regulation | | .725 | |
| Extraction Method: Principal Axis Factoring.<br>Rotation Method: Promax with Kaiser Normalization. | | | |

We find in Table 3.19 that Metacognitive knowledge and Metacognitive regulation are loading into one factor, which in this study is Metacognitive awareness, and Visual learning, Auditory learning and Kinesthetic learning are loading into one factor, which is Perceptual learning style preferences.

### 3.5.4 Achievement test in Biology

#### *3.5.4.1 Blueprint of the Achievement test*

Prior to developing the items for the achievement test, a blueprint was developed on the basis of which the questions for the test were constructed.

*Table 3.20 Weightage to Objectives*

| Domain | Percentage | Marks | No. of items |
|---|---|---|---|
| Remembering | 20% | 10 | 10 |
| Understanding | 20% | 10 | 8 |
| Application | 18% | 9 | 9 |
| Analyse | 18% | 9 | 8 |
| Evaluate | 12% | 6 | 4 |
| Create | 12% | 6 | 3 |
| **Total** | **100%** | **50** | **42** |

*Table 3.21 Weightage to Types of questions*

| Type of question | Percentage | Marks | No. of items |
|---|---|---|---|
| Objective type | 68 % | 34 | 34 |
| Short answer type | 32% | 16 | 8 |
| **Total** | **100%** | **50** | **42** |

*Table 3.22 Distribution of items according to the chapter and cognitive domains*

| Chapter | Remember | | Understand | | Application | | Analyse | | Evaluate | | Create | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O | S | O | S | O | S | O | S | O | S | O | S | |
| 1 | | | 2 (2) | | | | | 1 (2) | | | | 1 (2) | 4 (6) |
| 2 | 1 (1) | | | | | | | | | | | 1 (2) 1 (2) | 3 (5) |
| 3 | | | 1 (1) | 1 (2) | 1 (1) | | 2 (2) | | | 1 (2) | | | 6 (8) |
| 4 | 2 (2) | | | | 2 (2) | | 1 (1) | | | 1 (2) | | | 6 (7) |
| 5 | 2 (2) | | | | 1 (1) | | 1 (1) | | | | | 1 (2) | 5 (6) |
| 6 | 1 (1) | | 1 (1) | | | | 1 (1) | | | | | 1 (2) | 4 (5) |
| 7 | 1 (1) | | | 1 (2) | | 1 (2) | | | | | | | 3 (5) |
| 8 | 1 (1) | | 1 (1) | | | | | 1 (2) | | | | | 3 (4) |
| 9 | | | | | 1 (1) | | | | 1 (1) | | | | 2 (2) |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 1 (1) | | | | | | | | 1 (1) | | | | 2 (2) |
| 11 | | | | | 1 (1) | | | | | | | | 1 (1) |
| 12 | | | | | 1 (1) | | | | | | | | 1 (1) |
| 13 | 1 (1) | | | 1 (2) | | | 1 (1) | | | | | | 3 (4) |
| 14 | | | 1 (1) | | | | | | | | | 1 (2) | 2 (3) |
| 15 | | | | | | | 1 (1) | | 1 (1) | | | | 2 (2) |
| 16 | | | | 1 (2) | | 1 (2) | | | 1 (1) | | | | 3 (5) |
| Total | 10 (10) | | 6 (6) | 4 (8) | 7 (7) | 2 (4) | 7 (7) | 2 (4) | 4 (4) | 2 (4) | | 6 (12) | 50 (66) |

The blueprint given in Table 3.22 includes a total of 34 objective type questions and 16 short answer questions. The students are required to answer all 34 objective type questions but the short answer type questions comprise of 8 questions, each having two choices. Since each question has two choices, the total number of questions are 16. All the 16 questions have been included in the blueprint. The questions that are highlighted with similar colors are the pairs from which students are required to answer only one.

### *3.5.4.2 Development of preliminary draft*

The first draft of the achievement test consisted of 40 objective type questions and 20 short answer questions. Some extra questions were added to the first draft in case any deletions and replacements were required to be made based on the suggestions from experts.

### *3.5.4.3 Face validity and Content validity of the test*

Gay & Mills (2019) assert that content validity is especially crucial for achievement tests. If a test does not assess what a student was taught and should have learned, it cannot fairly represent a student's achievement. If the test includes material that hasn't been taught or doesn't cover material that has been taught, content validity will be jeopardised. As a result, the researcher ensured that the students took the test only after they had completed the Class 12 Biology syllabus.

After the first draft of the test was prepared, it was sent to Biology subject experts to:

• Examine the items critically for language and content;

• Clarify any ambiguities;

• Verify that the items accurately reflect the dimensions for which they have been developed;

• Make the required modifications in accordance with the feedback provided by the experts.

### *3.5.4.4 First pilot testing*

After receiving the necessary feedback and suggestions from subject experts, 34 objective type and 16 short answer type questions were retained. The 16 questions were paired such that students could choose one out of two choices for each question.

The preliminary draft was then pilot tested on 80 students for further standardization of the test.

### *3.5.4.5 Discrimination index and Difficulty value of the items*

An item analysis of the test was conducted to find out if the items are suitable for the test. It included calculating their discrimination values and difficulty indices.

For this, the scores obtained by the students in the Achievement test were taken.

| **Student** | **Marks obtained** | **Student** | **Marks obtained** | **Student** | **Marks obtained** |
|---|---|---|---|---|---|
| S1 | 43 | S20 | 31 | S39 | 28 |
| S2 | 39 | S21 | 31 | S40 | 28 |
| S3 | 38 | S22 | 31 | S41 | 27 |
| S4 | 38 | S23 | 30 | S42 | 27 |
| S5 | 37 | S24 | 30 | S43 | 27 |
| S6 | 35 | S25 | 30 | S44 | 27 |
| S7 | 35 | S26 | 30 | S45 | 27 |
| S8 | 34 | S27 | 30 | S46 | 27 |
| S9 | 34 | S28 | 30 | S47 | 26 |
| S10 | 34 | S29 | 30 | S48 | 26 |
| S11 | 33 | S30 | 30 | S49 | 26 |
| S12 | 32 | S31 | 29 | S50 | 26 |
| S13 | 32 | S32 | 29 | S51 | 26 |
| S14 | 32 | S33 | 29 | S52 | 25 |
| S15 | 32 | S34 | 29 | S53 | 25 |
| S16 | 32 | S35 | 28 | S54 | 25 |
| S17 | 32 | S36 | 28 | S55 | 25 |
| S18 | 32 | S37 | 28 | S56 | 25 |
| S19 | 32 | S38 | 28 | S57 | 25 |

| Student | Marks obtained | Student | Marks obtained | Student | Marks obtained |
|---|---|---|---|---|---|
| S58 | 25 | S67 | 20 | S76 | 13 |
| S59 | 24 | S68 | 20 | S77 | 13 |
| S60 | 24 | S69 | 20 | S78 | 10 |
| S61 | 23 | S70 | 18 | S79 | 10 |
| S62 | 23 | S71 | 16 | S80 | 6 |
| S63 | 23 | S72 | 16 | | |
| S64 | 23 | S73 | 16 | | |
| S65 | 22 | S74 | 15 | | |
| S66 | 22 | S75 | 15 | | |

After this, the scores of the top 27% (22 students) and bottom 27% (22 students) of the total test takers were calculated:

| Student | Marks obtained |
|---|---|
| S1 | 43 |
| S2 | 40 |
| S3 | 39 |
| S4 | 38 |
| S5 | 37 |
| S6 | 35 |
| S7 | 35 |
| S8 | 34 |
| S9 | 34 |
| S10 | 34 |
| S11 | 34 |
| S12 | 32 |
| S13 | 32 |
| S14 | 32 |
| S15 | 32 |
| S16 | 32 |
| S17 | 32 |
| S18 | 32 |
| S19 | 32 |
| S20 | 31 |
| S21 | 31 |
| S22 | 31 |

UPPER 27%

| Student | Marks obtained |
|---|---|
| S59 | 24 |
| S60 | 24 |
| S61 | 23 |
| S62 | 23 |
| S63 | 23 |
| S64 | 23 |
| S65 | 22 |
| S66 | 22 |
| S67 | 20 |
| S68 | 20 |
| S69 | 20 |
| S70 | 18 |
| S71 | 17 |
| S72 | 16 |
| S73 | 16 |
| S74 | 15 |
| S75 | 15 |
| S76 | 13 |
| S77 | 13 |
| S78 | 10 |
| S79 | 10 |
| S80 | 7 |

LOWER 27%

*Table 3.23 Difficulty values (DV) and Discrimination Indices (DI) of the items*

| Item | DV | Interpretation | Result | Action taken | DI | Interpretation | Result | Action taken |
|---|---|---|---|---|---|---|---|---|
| Q1 | 0.57 | Moderate | Keep | | 0.32 | Good item | Keep/Revise | |
| Q2 | 0.43 | Moderate | Keep | | 0.50 | Very good item | Keep | |
| Q3 | 0.59 | Moderate | Keep | | 0.27 | Mediocre item | Discard/Revise | Revised |
| Q4 | 0.43 | Moderate | Keep | | 0.32 | Good item | Keep/Revise | |
| Q5 | 0.86 | Very easy | Discard/ Revise | Revised | 0.09 | Poor item | Discard/Revise | Revised |
| Q6 | 0.82 | Very easy | Discard/ Revise | Revised | 0.27 | Mediocre item | Discard/Revise | Revised |
| Q7 | 0.89 | Very easy | Discard/ Revise | Revised | 0.23 | Mediocre item | Discard/Revise | Revised |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Q8 | 0.18 | Very difficult | Discard/ Revise | Revised | 0.27 | Mediocre item | Discard/Revise | Revised |
| Q9 | 0.41 | Moderate | Keep | | 0.45 | Very good item | Keep | |
| Q10 | 0.55 | Moderate | Keep | | 0.82 | Very good item | Keep | |
| Q11 | 0.50 | Moderate | Keep | | 0.36 | Good item | Keep/Revise | |
| Q12 | 0.59 | Moderate | Keep | | 0.73 | Very good item | Keep | |
| Q13 | 0.55 | Moderate | Keep | | 0.73 | Very good item | Keep | |
| Q14 | 0.57 | Moderate | Keep | | 0.68 | Very good item | Keep | |
| Q15 | 0.52 | Moderate | Keep | | 0.32 | Good | Keep/Revise | |
| Q16 | 0.43 | Moderate | Keep | | 0.41 | Very good item | Keep | |
| Q17 | 0.59 | Moderate | Keep | | 0.45 | Very good item | Keep | |
| Q18 | 0.59 | Moderate | Keep | | 0.55 | Very good item | Keep | |
| Q19 | 0.45 | Moderate | Keep | | 0.45 | Very good item | Keep | |
| Q20 | 0.52 | Moderate | Keep | | 0.50 | Very good item | Keep | |
| Q21 | 0.14 | Very difficult | Discard/ Revise | Revised | 0.27 | Mediocre item | Discard/Revise | Revised |
| Q22 | 0.16 | Very difficult | Discard/ Revise | Revised | 0.14 | Poor item | Discard/Revise | Revised |
| Q23 | 0.52 | Moderate | Keep | | 0.41 | Very good item | Keep | |
| Q24 | 0.50 | Moderate | Keep | | 0.55 | Very good item | Keep | |
| Q25 | 0.18 | Very difficult | Discard/ Revise | Revised | 0.18 | Poor item | Discard/Revise | Revised |
| Q26 | 0.80 | Easy | Keep/Revise | | 0.32 | Good item | Keep/Revise | |
| Q27 | 0.73 | Easy | Keep/Revise | | 0.36 | Good item | Keep/Revise | |
| Q28 | 0.25 | Difficult | Keep/Revise | | 0.41 | Very good item | Keep | |
| Q29 | 0.73 | Easy | Keep/Revise | | 0.36 | Good item | Keep/Revise | |
| Q30 | 0.55 | Moderate | Keep | | 0.55 | Very good item | Keep | |
| Q31 | 0.77 | Easy | Keep/Revise | Revised | 0.45 | Very good item | Keep | |
| Q32 | 0.41 | Moderate | Keep | | 0.45 | Very good item | Keep | |
| Q33 | 0.75 | Easy | Keep/Revise | Revised | 0.14 | Poor item | Discard/Revise | Revised |
| Q34 | 0.64 | Easy | Keep/Revise | | 0.45 | Very good item | Keep | |
| Q35 | 0.41 | Moderate | Keep | | 0.45 | Very good item | Keep | |
| Q36 | 0.59 | Moderate | Keep | | 0.64 | Very good item | Keep | |
| Q37 | 0.48 | Moderate | Keep | | 0.41 | Very good item | Keep | |
| Q38 | 0.43 | Moderate | Keep | | 0.41 | Very good item | Keep | |
| Q39 | 0.70 | Easy | Keep/Revise | | 0.50 | Very good item | Keep | |
| Q40 | 0.73 | Easy | Keep/Revise | | 0.55 | Very good item | Keep | |
| Q41 | 0.45 | Moderate | Keep | | 0.55 | Very good item | Keep | |
| Q42 | 0.32 | Difficult | Keep/Revise | | 0.36 | Good item | Keep/Revise | |

#### *3.5.4.6 Preparation of final draft of the test*

For the final draft of the test, a few questions were revised. None were deleted, they were only modified. The final draft of the test consisted of 34 multiple choice type questions of 1 mark each and 8 short answer type questions of 2 marks each. The total marks of the test was 50.

After the final draft of the test was prepared, norms of reference were developed by the investigator for the interpretation of the test scores as follows:

The test was administered on a sample of 80 students. Based on the scores obtained by the students, the z-score norms as shown in Table 3.24. and interpretation of the norms as shown in Table 3.25. were developed.

*Table 3.24 Z-score Norms for Achievement test*

| Raw scores | Z-scores |
|---|---|
| 45 | 1.66641 |
| 44 | 1.57870 |
| 43 | 1.49100 |
| 42 | 1.40329 |
| 41 | 1.31559 |
| 40 | 1.22788 |
| 39 | 1.14018 |
| 38 | 1.05247 |
| 37 | .96476 |
| 36 | .87706 |
| 35 | .78935 |
| 34 | .70165 |
| 33 | .61394 |
| 32 | .52623 |
| 31 | .43853 |
| 30 | .35082 |
| 29 | .26312 |
| 28 | .17541 |
| 27 | .08771 |
| 26 | .00000 |
| 25 | -.08771 |
| 24 | -.17541 |
| 23 | -.26312 |
| 22 | -.35082 |
| 21 | -.43853 |
| 20 | -.52623 |
| 19 | -.61394 |
| 18 | -.70165 |
| 17 | -.78935 |
| 16 | -.87706 |
| 15 | -.96476 |
| 14 | -1.05247 |
| 13 | -1.14018 |
| 12 | -1.22788 |
| 11 | -1.31559 |
| 10 | -1.40329 |
| 9 | -1.49100 |
| 8 | -1.57870 |
| 7 | -1.66641 |

*Table 3.25 Norms for Interpretation of Z-Scores for Achievement test*

| Academic achievement levels | z-score range | Range of scores |
|---|---|---|
| Very high achiever | +1.26 to 2.00 | 41 and above |
| High achiever | +0.51 to +1.25 | 32-40 |
| Average achiever | -0.50 to +0.50 | 20-31 |
| Low achiever | -0.51 to -1.25 | 12-19 |
| Very low achiever | -1.26 to -2.00 | 11 and below |

#### *3.5.4.7 Test-Retest reliability*

The reliability of the final draft of the achievement test was assessed using the Test-Retest method. The test and retest were conducted at an interval of three weeks. The reliability coefficient of the test was found to be 0.89, which denotes high reliability.

## 3.6 Data collection procedure

Prior to carrying out the field study in the state of Sikkim, the investigator obtained both verbal and written consent from the Education Department and Human Resource Development Department (HRDD) of the Government of Sikkim, India. With the HRDD's formal authorization, the investigator visited the senior secondary schools and gained approval from the respective heads of the institutions. The investigator then personally administered the instruments to the pupils. Before distributing the questionnaires, the investigator provided the participants of this study with an orientation to the purpose and goals of the study, in order to improve the validity of their responses. The researcher built a rapport with them, fostering trust and emphasising the significance of their involvement in the study. Data were gathered from a sample of 640 participants, with 635 individuals being included in the data analysis due to incomplete data provided by 5 respondents.

## 3.7 Data analysis

The collected responses were scored systematically by using the appropriate scoring keys. The relevant data collected from the sample were consolidated for the purpose of analysis. The names of the respondents along with their demographic details like gender, age, phone numbers (for future communication, if required), name of school, type of school and locality of school were systematically arranged. The data were

analysed using the Statistical Package for Social Sciences (SPSS 27). The following statistical measures were used for analysing the collected data: Mean, Standard deviation, Frequency, Percentages, Bar graphs, Skewness, Kurtosis, Normality test, Independent samples t-test, Chi square test, Pearson correlation and Regression.