CHAPTER IV

METHODOLOGY
A well-planned methodology that outlines the procedure in which the investigation is carried out is an essential pre-requisite for any systematic research. The vehicle of research cannot perform its function without it, since it is the methodology, which lays out the way that formal research is to be carried out and which outlines the detailed description of the research variables and procedures (Barr, 1960). Scientific reporting of methodology presumes that the details of the procedure adopted are adequately reported in terms of the method, tools used for collecting data, the details of the sample used for collection of data and the statistical procedures used for analysis of the data. The present chapter provides the details of the methodology used for conducting the study.

THE METHOD ADOPTED FOR THE STUDY

The normative survey method was found suitable for the study, as it mainly attempts to examine the influence of:

(a) select context variables on the acquisition of science process skills and achievement in science
(b) the acquisition of science process skills on achievement in science of the secondary school students of Kerala
(c) teacher-related variables on the instructional preferences of the science teacher.

Educational surveys are versatile and practical. The type of information the normative survey procures determines the present trends, as it is a method of investigation that describes what exists at present. They help to provide useful information on which sound decisions can be based and lead to advancement of knowledge.
Methodology

VARIABLES AND TOOLS USED FOR COLLECTING DATA

The study necessitated the measurement of the following variables:

1. Context variables - science instructional, motivational and familial – were measured using the Contextual Variable Scale (CVS), developed and validated by the investigator.

2. Science Process Skills – were measured using the Science Process Skill Elicitation Schedule (SPROSES), developed and validated by the investigator.

3. Achievement in Science – The grades assigned for the achievement in science were based on the data of the final examination marks, taken from the respective schools as per school records.

4. Instructional preferences of the science teachers – were measured using the Science Teachers’ Instructional Preference Analysis Scale (STIPAS), developed and validated by the investigator.

The data relating to the demographic variables (gender, location of school, management of the school) were gathered from the student response sheet provided along with CVS AND SPROSES. The data regarding teacher-related variables were gathered from the data sheet provided along with STIPAS.

A note on the Incident of Shifting of the Nature of Variables against Analysis of Changing in Pairs of Relationships:

The data obtained through the tools used were subjected for analysis for two sections of the population selected: (1) Students and (2) Teachers. In the Students’ category, interrelationships of pairs of variables from a group of three namely (1) Comprehensive Science Process Measures, (2) Context variables and (3) Achievement were attempted. In the Teachers’ category, two variables namely (1) Teacher - related variables and (2) Science Instructional Preferences were compared. A significant feature of the methods adopted for the study is that the investigation turned to a special case of multiple function of the same variable among different pairs of variables for the student category; where one variable functioned as ‘independent’ is taking the role of ‘dependent’ in another pair. Recent studies on process skills test design and implementation (Khanezi, 2005) and latest research methodology literature (Hefner C. L. and Seidel V. J., 2010) support this shift in nature of one variable among multiple pairs analytical combinations. The following diagram 4.1 clearly represents the practiced phenomenon in the current investigation.
Diagram 4.1: Diagrammatic representation illustrating the shift in the nature of the variables

<table>
<thead>
<tr>
<th>CATEGORY OF POPULATION</th>
<th>PAIRS GROUPED FOR ANALYSIS</th>
<th>INDEPENDENT VARIABLE</th>
<th>DEPENDENT VARIABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>STUDENTS</td>
<td>CONTEXT VARIABLES</td>
<td>CONTEXT VARIABLES</td>
<td>COMPREHENSIVE</td>
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<tr>
<td></td>
<td>Vs. COMPREHENSIVE SCIENCE</td>
<td></td>
<td>SCIENCE PROCESS</td>
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<td></td>
<td>PROCESS MEASURES</td>
<td></td>
<td>MEASURES</td>
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<tr>
<td></td>
<td>CONTEXT VARIABLES</td>
<td>CONTEXT VARIABLES</td>
<td>ACHIEVEMENT IN</td>
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<tr>
<td></td>
<td>Vs. ACHIEVEMENT IN SCIENCE</td>
<td></td>
<td>SCIENCE</td>
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<tr>
<td></td>
<td>COMPREHENSIVE</td>
<td></td>
<td>SCIENCE PROCESS</td>
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<td></td>
<td>SCIENCE PROCESS MEASURES</td>
<td></td>
<td>MEASURES</td>
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<tr>
<td></td>
<td>Vs. ACHIEVEMENT</td>
<td></td>
<td>SCIENCE</td>
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<tr>
<td></td>
<td>ACHIEVEMENT</td>
<td></td>
<td>SCIENCE</td>
</tr>
<tr>
<td>TEACHERS</td>
<td>TEACHER – RELATED</td>
<td>TEACHER – RELATED</td>
<td>SCIENCE</td>
</tr>
<tr>
<td></td>
<td>VARIABLES</td>
<td>VARIABLES</td>
<td>INSTRUCTIONAL</td>
</tr>
<tr>
<td></td>
<td>Vs. SCIENCE INSTRUCTIONAL</td>
<td></td>
<td>PREFERENCES</td>
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<tr>
<td></td>
<td>PREFERENCES</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Details of the tools used for data collection are given below.

1. **TOOL FOR MEASURING THE SELECT CONTEXT VARIABLES:**

   **CONTEXTUAL VARIABLE SCALE (CVS)**

   The present study used a standardized scale of select context variables, by name “Contextual Variable Scale”. The details relating to the scale are described below.
A review of the related literature and tools available to analyse the various school, home and personal factors of the science learner, made the investigator feel the dearth of a good tool which is relevant to the present educational scenario that advocates constructivist pedagogy, activity-based and child-centred learning approach. “The Taxonomy of Science Education” (Mc Cormack, Yager, 1989) which had received wide support from science educationalists, stressed that science education should give emphasis to the following domains: knowledge, science process, creativity, attitudinal and application domains. The level of involvement of the learner in each/all of these domains would influence his/her achievement in science and acquisition of science process skills. These are in turn influenced by various factors in and out of the school.

The achievement in science as well as the science process skills are not merely attained through the transactions in the classroom. Several other context factors –like, factors inside the school setting as well as factors from the home and community, intrinsic and extrinsic motivation to learn science, etc., that could be termed as science instructional, familial and motivational - may have an influence. Hence the study tries to establish the relationship between the select context variables and the acquisition of science process skills and achievement on science.

With the goal of analyzing the impact of the context variables on the secondary school science learner, the investigator developed and standardized the Contextual Variable Scale (CVS). The context variables selected for the study are:

- factors within the school : science instructional,
- factors within the home : familial
- factors within the student : motivational variable.

The Iowa Assessment Handbook (Sandra K. Enger & Robert E. Yager, 1998) and Student Instruction and Motivation Survey (Geoff Giddings, 1993) were mainly used as the primary reference for developing the preliminary draft of the tool.
a) **Preliminary draft:**

With the help of the primary reference materials and due emphasis on the five domains stated in the Teacher’s Handbook of Basic Science at the secondary level (Government of Kerala, Education Department, 2009), the investigator initially pooled 110 statements distributed over three areas:

- **In the science class...** relating to science instructional (40 items),
- **As I learn science....** relating to student motivational (40 items)
- **In my home/family....** relating to familial variable (30 items).

These statements were given to experts to evaluate the content accuracy of each item, coverage and significance with regard to the science educational scenario prevailing in the state. Even though the experts agreed with the investigator on the accuracy, objectivity and relevance of the statements, they suggested a reduction in the total number of statements considering the feasibility for the administration of the test. Based on the 90% unanimity (agreement) of the experts, only 90 statements were retained for the try-out/pilot study of the tool.

The draft form of The Contextual Variable Scale comprising of 30 statements each under the variable: science instructional- **In the science class...**., motivational- **As I learn Science....** and familial- **In my home/family....** were framed and listed from 1 to 90 of which statement numbers 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 and 90 were negative statements. In addition to their demographic information, the students were asked to circle the letter which best match their viewpoint for each statement using the following categories in the five-point Likert Scale:

- a- Strongly agree
- b- Agree
- c- Not Sure
- d- Disagree
- e- Strongly disagree.
The draft form of the Contextual Variable Scale is shown in appendix i

**Specimen Statements under the context variable ‘science instructional’:**

*In my science class,*

I enjoy science lessons as my teacher shows good interpersonal relations with us.

My teacher poses questions that elicit our thinking.

What I learn about science is of no use to me in my daily life.

**Specimen Statements under the context variable ‘motivational’:**

*As I learn science,*

I wish to investigate my own science questions.

I maintain a science dairy to record something relevant/curious about science.

What I learn never encourages me to think.

**Specimen Statements under the context variable ‘familial’:**

*In my home/family,*

I get enough appreciation for my efforts/achievements in science.

I do activities which help me to understand the science I have learnt.

No one listens to my explanation of the scientific reason behind incidents.

**Try-out**

The draft form of The Contextual variable Scale was then administered on 86 secondary school students adhering to the required government/private, boys/girls, rural/urban sub samples of Thiruvananthapuram and Ernakulam districts of Kerala with prior permission from the respective school principals. The range of time in which the students completed the scale was determined. The student who finished first took 30 minutes while the one who finished last took 55 minutes. On an average, the students took 40 minutes to complete the scale. The students were able to comprehend the statements and responded well.
Scoring

The statements were scored giving weightage to each of the alternate response of the statement in the pattern given below for all the positive statements.

- Strongly agree 5
- Agree 4
- Not Sure 3
- Disagree 2
- Strongly disagree 1

For all the negative statements of the scale, scoring was reversed ranging from 1 to 5.

Statistical Analysis

The data obtained for the try-out was statistically analysed to establish the reliability and validity of the tool, CVS.

Reliability

Reliability is one of the most important elements of the quality of a tool. It has to do with the consistency or reproducibility of an examinee’s performance on the tool. Reliability is usually expressed as a coefficient of correlation, whose value range from 0.00 (no reliability) to 1.00 (perfect reliability). The reliability statistics of the 90 statements of the developed tool was found to be 0.954, showing high reliability of the scale. As per the item analysis, 11 statements (statements 10, 15, 20, 25, 45, 47, 50, 70, 80, 85 & 90) were deleted to improve the reliability of the final scale intended for the main study.

The final form of Contextual Variable Scale contains a total of 79 statements (science instructional - 26 statements, motivational – 27 statements, familial – 26 statements) listed from 1 to 79 variable wise. Statement numbers 5, 26, 31, 36, 48, 53, 58 and 67 are negative statements. The estimated time for completion of the test is 40 minutes. The final form of Contextual Variable Scale (English and Malayalam versions) is shown in appendix ii.
The table 4.1 shows the reliability statistics of the final **CVS** having 79 items.

**Table 4.1: Reliability of the final Contextual Variable Scale**

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Reliability Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha</td>
<td>0.965</td>
</tr>
<tr>
<td>1st half Vs 2nd half</td>
<td>0.916</td>
</tr>
<tr>
<td>Odd &amp; Even Method</td>
<td>0.962</td>
</tr>
</tbody>
</table>

The above high values (> 0.900) indicate that the scale maintains an internal consistency over time and is capable of obtaining the same score from the same student at different administration (given the same conditions). Hence the investigator establishes that the Contextual Variable Scale is a reliable tool to analyse the various school, home and personal factors of the science learner in the present educational scenario.

### Validity

Validity is arguably the most important criteria for the quality of a tool. Validity is the extent to which a tool measures what it claims to measure. It is vital for a tool to be valid in order for the results to be accurately applied and interpreted. For a tool to be valid, it must be reliable. The following types of validity were analysed for the developed Contextual Variable Scale.

**(a) Content Validity**

Content validity concerns, primarily, the adequacy with which the test items adequately and representatively sample the content area to be measured. Expert judgement is the primary method used to determine whether a test has content validity. The preliminary draft of The Contextual Variable Scale was given to experts in the field of science education (high school science teachers and teacher educators) and discussions were made regarding the statements included under the three selected context variables. Accordingly, modifications were done before finalizing the tool and its administration. Hence, The Contextual Variable Scale...
possesses content validity as the statements were selected based on the 92% unanimity of experts on content adequacy, conceptualization and distribution of statements over the three selected context variables.

(b) Item validity

The items for the final scale were selected by item total analysis and taking the ‘t’ values of the items which had a significance of 0.05 level or higher. The reliability value of the scale if each item deleted was computed and the 79 statements were finalized.

(c) Intrinsic Validity

The scale possesses intrinsic validity since the index of reliability was taken as the intrinsic validity by working out the square roots of the reliability coefficients of the scale. The validity scores of the final scale were obtained as 0.982, 0.957 and 0.981. The table 4.2 show the validity statistics of the final Contextual Variable Scale.

Table 4.2: Validity of the final Contextual Variable Scale

<table>
<thead>
<tr>
<th>Validity</th>
<th>*Intrinsic Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach's Alpha</td>
<td>0.982</td>
</tr>
<tr>
<td>1st half Vs 2nd half</td>
<td>0.957</td>
</tr>
<tr>
<td>Odd &amp; Even Method</td>
<td>0.981</td>
</tr>
</tbody>
</table>

*Intrinsic validity is the square root of Reliability Index

The above validity indices of The Contextual Variable Scale indicate that it is a valid tool to analyze the various school, home and personal factors of the science learner in the present educational scenario.

The mean and standard deviation of the final scale were 343.093 & 43.38 respectively. The standard error of measurement of the final scale was computed and found to be low (8.11), which further indicates the high reliability of the scale.
It is thus established that the **Contextual Variable Scale** is a valid and reliable tool conducive for the present study to analyze the impact of the context variables - science instructional, motivational and familial - on the secondary school science learner, which would give valid scores to measure the select context variables of the present study.

2. **TOOL FOR MEASURING COMPREHENSIVE SCIENCE PROCESS MEASURES: SCIENCE PROCESS SKILL ELICITATION SCHEDULE (SPROSES)**

The study was aimed to assess the acquisition of various basic as well as integrated science process skills of the secondary school science learners. To this end, the investigator developed and standardized the Science Process Skill Elicitation Schedule (SPROSES) based on the following:

- An in-depth analysis of the various basic and integrated science process skills that are to be acquired by a secondary school science learner.
- The thirteen science process skills identified by AAAS in the development of **Science: A Process Approach (SAPA)** consisting of 8 basic science process skills and 5 integrated science process skills.
- The competency indicators of various science process skills reflecting the kinds of tasks that can be used to assess the learner’s use of process skills (Harlen & Elstgeest, 1993). These indicators were expressed in terms of what a learner would be doing when using the process skills.
- The Iowa Assessment Handbook (Enger & Yager, 1998)
- The Teacher’s Handbook of Basic Science at the secondary level (Government of Kerala, Education Department, 2009).

A major consideration in developing a tool to test the science process skills is that of format. Dillashaw and Okey pointed out that, while one requires students to demonstrate competence in science process skills, the problem of using hands-on procedures to assess acquisition of skills could be a burdensome task. The paper
and pencil group-testing format is therefore more convenient when assessing science process skills competence, especially in large under-resourced science classes, with the understanding that science process skills are relatable to higher order thinking skills (Dillashaw and Okey, 1980, Onwu and Mozube, 1992).

For the present study, the multiple-choice format was perceived as the most feasible format, despite some of the weakness associated with it, such as no provision for the reasons for the selection of a particular option. Multiple-choice questions are widely used in educational systems. Multiple-choice questions are credited with many advantages, which tend to offset their weakness. The investigator’s decision to use the multiple-choice format was influenced by the following advantages.

- Multiple-choice questions can be set at different cognitive levels. They are versatile if appropriately designed and used (Higgins and Tatham, 2003).
- Multiple-choice questions can be easily administered especially for large classes.
- The scoring of multiple-choice questions can be very accurate and objective. So variations in marking due to subjective factors are eliminated and do not require an experienced tutor to mark them (Higgins and Tatham, 2003).
- Multiple-choice questions can provide a better coverage of content and assessment can be done in a short period of time.
- Multiple-choice questions can easily be analysed statistically, not only to determine the performance of the learners, but the suitability of the question and its ability to discriminate between learners of different competencies.
- Multiple-choice questions focus on the reading and thinking skills of the learner. They do not require the learner to have writing skills, which may hinder the demonstration of competence in the necessary skills.
Development of the tool, SPROSES

The test items relating to each of the science process skills were developed on the basis of the possible tasks that reflect the competency indicators in the context of a multiple choice test. The process skill based questions were created as to

1. describe a situation which is familiar to the science learner, but in which the details are unique.
2. give a task which can only be attempted by using a process skill.
3. avoid problems where the answer could be provided by recall and
4. avoid limiting the test items centering on a specific content/curriculum.

The developed test items for each science process skill and its relevant competency indicators were given to experts in the field of science education (secondary school science teachers and science teacher educators) to assess the ability of the test item to elicit the particular skill of the learner, to check content adequacy and the plausibility of the four options given for each test item. Discussions were made regarding the indicators and the inclusion of test items under each science process skill. Accordingly, modifications were done. The test items were then mixed and compiled. The competency indicators relating to the science process skills are shown in the appendix iii. The preliminary draft of the tool – Science Process Skill Elicitation Schedule (SPROSES) was finalized to a total of 70 test items relating to 8 basic science process skills and 5 integrated science process skills. The draft form of SPROSES, select science process skills their concerned test item numbers, and the answer key are attached in the appendix iv (a) and iv (b).
Specimen test item under each science process skill

(a) Basic Science Process Skills

1. Observing
Observe the two pictures. Are they identical? If not, how many differences can you spot among them?

![Two pictures of a boy working on a desk]

a) 5  b) more than 5  c) less than 5  d) none
Ans: b

2. Classifying
Which would be the best feature to use in classifying all the objects in the following figure?

![Variety of shapes]

a) circle vs triangle
b) square vs not a square
c) no straight sides vs four straight sides
d) curved edge vs straight edge.
Ans: d
3. Using Numbers

Ben started his journey at 6:15 and reached home at 18:30. How long was the journey time?

a) 12 hours 45 minutes  
b) 11 hours 45 minutes

c) 11 hours 15 minutes  
d) 12 hours 15 minutes

Ans: d

4. Using time/space relations

Observe the picture. If two runners start at the same time from points A and B and arrive at the finish line C at the same moment, who runs faster?

a) The runner from point A is faster than the runner from point B.

b) The runner from point B is faster than the runner from point A.

c) The runner from points A and B raced at the same speed.

d) The runner from point B is slower the runner from point than A.

Ans: b

5. Inferring

The human heart is a powerful pump that ceaselessly supplies blood to each and every part of the body. The pulse tells you about the condition of the heart. The normal pulse rate at rest, ranges from 60-100 beats per minute (bpm) in human adults. It was observed that Sam had a pulse rate of 123 bpm after an exercise session in the morning. This shows that

a) Sam’s heart pumps blood faster during exercises.

b) Sam’s heart pumps blood slower during exercises.

c) Sam is having abnormal heartbeat.

d) Sam is facing the risk of a heart attack.

Ans: a
6. Communicating

John is trying to draw a sketch of his school classroom in his notebook. A convenient scale for him to use would be

a) 1 cm = 1 mm  b) 1 cm = 1 cm  
c) 1 cm = 1 m  d) 1 cm = 1 km

Ans: c

7. Measuring

A burette is a vertical cylindrical piece of laboratory glassware. Burettes measure from the top since they are used to measure liquids dispensed out the bottom. The burette reading shown in the fig A is 9.6 ml. The burette reading shown in the figure B is .............

![Burette Fig A](image1)

![Burette Fig B](image2)

a) 24 ml  b) 25.8 ml  c) 23.9 ml  d) 24.1 ml

Ans: c

8. Predicting

Combustion is the burning of a substance in air. Oxygen in the air is a supporter of combustion. What happens if a burning candle is covered by a glass tumbler?

a) the candle continues to burn  
b) the candle burns less brightly  
c) the candle burns more brightly  
d) the candle is put off after some time

Ans: d
(b) Integrated Science Process Skills

9. Defining operationally

Sally planted bean seedlings in three pots of the same size, but having different types of soil. She wanted to know whether the type of soil would affect the growth of bean plants. The pots were placed near a sunny window and watered with the same amount of water everyday. The differences in the plant growth were recorded after a week.

The term ‘plant growth’ as stated in the question refers to:

a) Height of the plant as measured from the top of the soil to the tip of its stem.
b) Height of the plant as measured from the tip of the root to the tip of its stem.
c) Height of the plant as measured from the base of the pot to the tip of its stem.
d) Height of the plant as measured from the tip of the root to the base of the pot.

Ans: a

10. Interpreting data

The world population is the totality of all living humans on the planet Earth. The following graph relates to world population growth.

![World Population Growth Graph](image)

Which of the following statements are true, according to the above graph?

a) The world population decreases continuously.
b) The world population is decreasing in the recent years.
c) The world population decreases steadily.
d) The world population has experienced continuous growth.

Ans: d
11. Identifying and controlling variables

A farmer wanted to increase the yield of his crop. He decided to study the factors that affect the yield of the crop produced. Which of the following factors could he control in his investigation?

a) amount of fertilizer added and quality of seeds used
b) amount of rainfall and amount of sunlight
c) amount of sunlight and amount of fertilizer added
d) amount of wind and quality of seeds used

Ans: a

12. Experimenting

Manoj thinks that the more the air pressure in a football, the farther it moves ahead when kicked. To investigate this, he uses several footballs and an air pump with a pressure gauge. What should Manoj do to conduct the investigation?

a) Kick the footballs having different air pressure from different points on the ground with different amount of forces.
b) Kick the footballs having different air pressure from the same point on the ground with the same force.
c) Kick a football with different amounts of force from the same point on the ground.
d) Kick the footballs having the same air pressure at various angles on the ground.

Ans: b

13. Formulating hypothesis

Leena washed four towels and hung them up in different places to make it dry. She wanted to see if the places made any difference to how quickly they dried. Which of these places do you think the towel would dry quickest?

a) in a cool room by an open window
b) in a warm room by an open window
c) in a warm room by a closed window
d) in a cool room by an closed window

Ans: b
Try-out

The draft form of The Science Process Skill Elicitation Schedule was electronically typed and made into reusable test booklets and were administered to 103 secondary school students adhering to the required government / private, boys / girls, rural / urban sub-samples of Thiruvanathapuram and Ernakulam districts of Kerala with prior permission from the respective school principals. The response sheet was prepared separately which had provision for marking the demographic information of the learner and their responses to the test items of SPROSES.

The response sheets and the booklets were collected back as soon as the students finished responding and the time taken was noted on all the response sheets. The range of time in which the students completed SPROSES was determined. The student who finished first took 35 minutes while the one who finished last took 75 minutes. On an average, the students took 45 minutes to complete the SPROSES. The students were able to comprehend the test items and responded well.

Scoring

The SPROSES was of the multiple choice question type with four alternatives and the students were asked to indicate their response to a test item by putting a cross-mark in the box corresponding to their choice provided in the response sheet. The responses were scored according to the answer key prepared by the investigator and verified by the experts. Each correct response scored one mark while wrong/ unattended ones scored zero. The final score was calculated as the sum of the scores of individual test items.
Statistical Analysis

Item analysis is a crucial aspect of test construction, as it helps determine the items that need improvement or deletion from a test instrument. Item analysis refers to the process of collecting, summarizing, and using information from learners’ responses, to make decisions about each assessment task (Nitko, 1996). One of the purposes of item analysis is to obtain objective data that signals the need for revising the items, so as to select and cull items from a pool (Nitko, 1996). This was the primary reason for doing item analysis in this study. The two central concepts in item analysis, especially in the context of this study are; index of difficulty and discrimination index.

Developing the perfect test is the unattainable goal for anyone in an evaluative position. Even when guidelines for constructing fair and systematic tests are followed, a plethora of factors may enter into a student’s perception of the test items. Looking at an item’s index of difficulty and discrimination index will assist the test developer in evaluating the individual test items.

The data obtained for the try-out was statistically analysed. Item analysis of the test was performed to evaluate the test items and to eliminate unfair/poor items, for selection into the final SPROSES intended for the main study. The subjects were divided into high, middle, and low scorer performance categories. These performance categories were determined by first arranging all the students’ scores on the test in a descending order. Secondly, the subjects whose scores fell in the upper 27% of the ranking were considered to be high scorers, while those whose scores fell in the lower 27% of the ranking were considered to be low scorers. The remaining students were considered to be medium scorers. For each test item, the percentage of students who selected the correct response from each of the high group and low group were determined and accordingly the discrimination index and the difficulty index were calculated for each test item.
Discrimination index

A good test item discriminates between those who do well on the test and those who do poorly. Discrimination can be examined by comparing the number of persons getting a particular item correct with the total test score. Item discrimination index determines whether those who did well on the entire test did well on a particular item. If a particular item is doing a good job of discriminating between those who score high and those who score low, more people in the top-scoring group will have answered the item correctly. The higher the discrimination index, the better the item because such a value indicates that the item discriminates in favour of the upper group, which should get more items correct.

As a rule of thumb, in terms of discrimination index, 0.40 and greater are very good items, 0.30 to 0.39 are reasonably good but possibly subject to improvement, 0.20 to 0.29 are marginal items and need some revision, below 0.19 are considered poor items and need major revision or should be eliminated (Ebel & Frisbie, 1986).

Accordingly, those test items whose discrimination index is below 0.3 were deleted for the final study. The discrimination index for the final SPROSES was found to be 0.5586, which indicate the higher discriminating power of the tool.

Index of difficulty

It is necessary for a test to be composed of items of varying levels of difficulty. Item difficulty is simply the percentage of students taking the test who answered the item correctly. In test construction, item difficulty is determined by the number of people who answer a particular test item correctly. The higher the percentage of people who answer correctly, the easier is the item. The higher the difficulty index, the easier the item is understood to be (Wood, 1960). A test instrument with an index of difficulty of more than 0.6 is considered to be too easy.
(Nitko, 1996). In this study, a difficulty index range of 0.4 to 0.6 was considered appropriate for the inclusion of an item in the test instrument. Test items that fall outside this were deleted in the final SPROSES.

The item analysis necessitated the deletion of 20 test items. The indices of discrimination and difficulty of the final SPROSES were determined to be 0.5586 and 0.5526 respectively. The high value of discrimination index indicates that the SPROSES is a good tool to assess the science process skills of the secondary science learner, as it could clearly discriminate between learners who are competent in science process skills and those who are not. The desired index of difficulty indicates SPROSES is a good tool for assessing the acquisition of science process skills among good, average and weak science learners. The descriptive statistics of SPROSES is as given in the table 4.3

<table>
<thead>
<tr>
<th>Table 4.3: Descriptive statistics of SPROSES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N</strong></td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>TOTAL SCORE</td>
</tr>
</tbody>
</table>

**Reliability and Validity**

A valid and reliable test should have test characteristics that fall within the accepted range of values, for each characteristic, such as validity, reliability, discrimination index, index of difficulty, and it should not be biased against any designated sub-group of test takers. The reliability and related statistics of the final SPROSES is as shown in the table 4.4.
Table 4.4: The reliability and related statistics of the final SPROSES

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Value</th>
<th>Acceptable Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s Alpha</td>
<td>0.907</td>
<td>&gt;= 0.70</td>
</tr>
<tr>
<td>Split half (First &amp; Second)</td>
<td>0.82</td>
<td>&gt;= 0.70</td>
</tr>
<tr>
<td>Split half (Odd &amp; Even)</td>
<td>0.901</td>
<td>&gt;= 0.70</td>
</tr>
<tr>
<td>Discrimination index</td>
<td>0.5586</td>
<td>&gt;= 0.30</td>
</tr>
<tr>
<td>Index of difficulty</td>
<td>0.5526</td>
<td>0.4 – 0.6</td>
</tr>
<tr>
<td>Standard error of measurement</td>
<td>4.41</td>
<td>low</td>
</tr>
</tbody>
</table>

The reliability of a test instrument can also be expressed in terms of the standard error of measurement (Gay, 1987). The standard error of measurement helps us to understand that the scores obtained on educational measures are only estimates, and may be considerably different from an individual’s presumed true scores (Gall and Borg, 1996). The standard error of measurement measures the distance of learners’ obtained scores from their true scores (Nitko, 1996). A small standard error of measurement indicates a high reliability, while a large standard error of measurement indicates low reliability (Gay, 1987). In this study, the low value of the standard error of measurement (4.41) further confirmed the reliability of the developed tool.

SPROSES possesses content validity as the statements were selected based on the 92% unanimity of experts on content adequacy, conceptualization and distribution of statements over the selected science process skills.

Item validity

The items for the final score were selected by item total analysis and taking the ‘t’ values of the items which had a significance of 0.05 level or higher. The reliability value of the scale if each item deleted was computed and the 50 questions were finalized.
Intrinsic Validity

The scale possesses intrinsic validity since the index of reliability was taken as the intrinsic validity by working out the square roots of the reliability coefficients of the scale. The validity scores of the final SPROSES having 50 items are shown in the following table 4.5.

<table>
<thead>
<tr>
<th>Validity</th>
<th>Intrinsic validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s Alpha</td>
<td>0.952</td>
</tr>
<tr>
<td>1) 1st half Vs 2nd half</td>
<td>0.906</td>
</tr>
<tr>
<td>2) Odd &amp; Even Method</td>
<td>0.950</td>
</tr>
</tbody>
</table>

*Intrinsic validity is the square root of Reliability Index

The final SPROSES consists of 32 test items for assessing the basic science process skills and 18 test items for assessing the integrated process skills. The reliability and validity statistics relating to the test items assessing the basic and integrated science process skills as shown in the following table indicate their high reliability and validity. The estimated time for completion of the test is 45 minutes. The final form of SPROSES, the various test items classified under basic /integrated science process skills, answer key and the response sheet are shown in appendix v (a) to v (c). The reliability and validity statistics relating to the test items assessing the basic and integrated science process skills were also analysed and the results are shown in the table 4.6.
Table 4.6: The reliability and validity statistics relating to the test items assessing the basic and integrated science process skills

<table>
<thead>
<tr>
<th></th>
<th>Reliability</th>
<th>Intrinsic validity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic skills</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cronbach’s Alpha</td>
<td>0.846</td>
<td>0.92</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; half Vs 2&lt;sup&gt;nd&lt;/sup&gt; half</td>
<td>0.746</td>
<td>0.86</td>
</tr>
<tr>
<td>Odd &amp; Even Method</td>
<td>0.861</td>
<td>0.93</td>
</tr>
<tr>
<td><strong>Integrated process skills</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cronbach’s Alpha</td>
<td>0.790</td>
<td>0.89</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; half Vs 2&lt;sup&gt;nd&lt;/sup&gt; half</td>
<td>0.705</td>
<td>0.84</td>
</tr>
<tr>
<td>Odd &amp; Even Method</td>
<td>0.850</td>
<td>0.92</td>
</tr>
</tbody>
</table>

It is thus established that *Science Process Skill Elicitation Schedule (SPROSES)* is a valid and reliable tool conducive for the present study to assess the acquisition of the various basic and integrated science process skills of the secondary science learner, which would give valid scores to the comprehensive science process measures dealt in the study.

3. TOOL FOR MEASURING THE ACHIEVEMENT IN SCIENCE

The researcher faced the obstacle of developing three different achievement test in science (Physics, chemistry, biology) for the two levels (standards VIII and IX). Also, the three tests for each are to be administered to the same set of students on whom CVS and SPROSES are to be administered. The school authorities, when contacted, were reluctant to devote their time towards this. Instead they agreed to the supervisor’s request for revealing the data relating to the achievement in science of the students in the final examination, for the purpose of the study. The results of the examinations were considered valid as the question papers and scoring key for the examinations were supplied by competent regional bodies of teacher associations endorsed by the Government of Kerala with
the same. The marks thus obtained were converted into grades based on set criteria (as shown in the table 4.7) and were adopted for the purpose of using as reference score, for further analysis with the scores obtained through the tools (CVS & SPROSES) developed and used by the investigator.

Table 4.7: Criteria for grading achievement in science scores

<table>
<thead>
<tr>
<th>Grade</th>
<th>Criteria of grading</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>80 % to 100% marks</td>
</tr>
<tr>
<td>B</td>
<td>60 % to 79%</td>
</tr>
<tr>
<td>C</td>
<td>40% to 59%</td>
</tr>
<tr>
<td>D</td>
<td>Below 40%</td>
</tr>
</tbody>
</table>

4. **TOOL FOR MEASURING THE INSTRUCTIONAL PREFERENCES OF THE SCIENCE TEACHERS: SCIENCE TEACHERS’ INSTRUCTIONAL PREFERENCE ANALYSIS SCALE (STIPAS)**

Science teaching is a composite profession requiring knowledge and skills in both science and education. The best teachers tend to be goal-focused, but flexible and reflective. These characteristics allow them to relate to the learners and to modify and improve their practices. The achievement in science as well as the acquisition of science process skills by the learner is governed by the various events that take place inside the science classroom. It is the science teacher who has a pivotal role in being a learning consultant and mentor about learning for his/her students. The teaching experience, exposure to professional development, and the infrastructural facilities relating to science education available at school may act as decisive factors on the instructional preferences and hence to the professional competency of the science teachers.
The present study intends to probe into the instructional preferences of the science teacher in the present educational scenario that advocates constructivist pedagogy, activity-based and child-centred learning approach. The review of literature as well as the experience of the investigator as a science teacher and teacher educator paved the way to arrive at the following ten science teacher instructional preference categories, as shown in table 4.8, considered vital for the science teacher in the classroom:

**Table 4.8: Science teacher instructional preference categories**

<table>
<thead>
<tr>
<th>No.</th>
<th>Science Teacher Instructional Preference</th>
<th>Abbreviation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher- Pupil Interaction Dynamics</td>
<td>TPID</td>
</tr>
<tr>
<td>2</td>
<td>Influence of Life-Skill Integration</td>
<td>ILSI</td>
</tr>
<tr>
<td>3</td>
<td>Flexible cum Viable Instructional Strategy Integration</td>
<td>FISI</td>
</tr>
<tr>
<td>4</td>
<td>Process Skill Application in Procedures</td>
<td>PSAP</td>
</tr>
<tr>
<td>5</td>
<td>Styles of Meta-Cognitive Strengthening</td>
<td>SMCS</td>
</tr>
<tr>
<td>6</td>
<td>Adaptation of Multi-Pronged Assessment Techniques</td>
<td>AMAT</td>
</tr>
<tr>
<td>7</td>
<td>Adoption of the Spirit of Inter-Disciplinarity</td>
<td>ASID</td>
</tr>
<tr>
<td>8</td>
<td>Technology Woven Procedural Enrichment</td>
<td>TWPE</td>
</tr>
<tr>
<td>9</td>
<td>Preference for Quality of Life Enhancement</td>
<td>PQLE</td>
</tr>
<tr>
<td>10</td>
<td>Professional Growth and Auto- Empowerment</td>
<td>PGAE</td>
</tr>
</tbody>
</table>

*Note: These abbreviations that appear elsewhere in the report refers to the corresponding instructional preference of the science teacher.

With the goal of analyzing the instructional preferences of the science teachers in Kerala, the investigator developed and standardized the Science Teachers’ Instructional Preference Analysis Scale (STIPAS). The Iowa Assessment Handbook (Sandra K. Enger & Robert E. Yager, 1998), Expert Science Teacher Educational Evaluation Model (Judith A. Burry-Stock, 1993) and Standards for Science Teacher Preparation (NSTA, 2003) were mainly used as the primary reference for developing the preliminary draft of the tool.
Preliminary draft:

With the help of the primary reference materials and due emphasis on the five domains stated in the Teacher’s Handbook of Basic Science at the secondary level (Government of Kerala, Education Department, 2009), the investigator initially pooled 60 statements distributed over the stated ten science teacher instructional preference categories. These statements were given to experts to evaluate their content accuracy, coverage and significance with regard to the science educational scenario prevailing in the state. The experts agreed with most of the statements on the accuracy, objectivity and relevance of the statements. Based on the 90% unanimity of the experts, a few statements were modified.

**Specimen statements:**

In my science class,

- I encourage active participation of my students throughout the lesson. (TPID)*
- I provide evidence to my students as of how a concept is correlated to their everyday life. (ILSI)
- I ensure that my students are actively engaged in gaining physical or mental learning experiences throughout the lesson. (FISI)
- I ensure that content and science process skills are integrated throughout the lesson. (PSAP)
- I lead my students through different cognitive levels to reach higher order thinking skills. (SMCS)
- I use multiple forms of assessments to ascertain what my students know and can do as a result of their science learning experiences. (AMAT)
- I maintain a supportive learning environment, facilitating interdisciplinary learning. (ASID)
- I impart a visual treat to my students using ICT presentations on the topics taught. (TWPE)
Methodology

- I initiate my students to take individual decisions in diet, health, lifestyles etc. based on their science learning experiences. (PQLE)
- I use information from students, colleagues and others to improve teaching and facilitate professional growth. (PGAE)

*Note: The abbreviations stand for the science teacher instructional preference category, as illustrated earlier.

The draft form of The Science Teachers’ Instructional Preference Analysis Scale comprising of 40 positive and 20 negative statements was administered to 30 secondary school science teachers adhering to the required government/private, boys/girls, rural/urban areas of Thiruvananthapuram and Ernakulam districts of Kerala with prior permission from the respective school principals. In addition to the information regarding the teacher - related variables (teaching experience, number of in-service courses attended in the last two years, rating of the laboratory facilities at school), the science teachers were asked to circle the letter which best matches with their perception of science teaching, using the following categories on the five-point Likert Scale:

a- Always               b- Often               c- Sometimes
 d- Seldom              e- Never

The draft form of STIPAS, the ten science teacher instructional preference categories and their corresponding statement numbers is shown in appendices vi (a) and vi (b)

Scoring

The statements were scored giving weightage to each of the alternate response of the statement in the pattern given below for all the positive statements.

a- Always               5
b- Often                4
c- Sometimes             3
d- Seldom                2
e- Never                1
For all the negative statements of the scale, scoring was reversed ranging from 1 to 5.

**Statistical Analysis**

The data obtained for the try-out was statistically analysed to establish the reliability and validity of the tool, STIPAS.

**Reliability**

Reliability is one of the most important elements of the quality of a tool. Reliability is usually expressed as a coefficient of correlation, whose value range from 0.00 (no reliability) to 1.00 (perfect reliability). The reliability statistics of the 60 statements of the developed tool was found to be 0.926, showing high reliability of the scale. As per the item analysis, 7 statements (statements 3, 13, 15, 24, 39, 47 & 57) were deleted to improve the reliability of the final scale intended for the main study.

The final form of Science Teachers’ Instructional Preference Analysis Scale contains a total of 53 statements of which statement numbers 5, 8, 11, 15, 18, 23, 26, 29, 32, 37, 40, 42, 45, 48 and 53 are negative statements. The required time as estimated for completing STIPAS is 30 minutes. The final form of STIPAS and the statement numbers corresponding to each instructional preference category is shown in appendices vii (a) and vii (b).

The following table 4.9 shows the reliability statistics of the final Science Teachers’ Instructional Preference Analysis Scale having 53 items.
### Table 4.9: Reliability of the final STIPAS

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Coefficient of correlation</th>
<th>Reliability Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cronbach’s Alpha</td>
<td>-</td>
<td>0.868</td>
</tr>
<tr>
<td><strong>Split half method</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) 1\textsuperscript{st} half Vs 2\textsuperscript{nd} half</td>
<td>0.874</td>
<td>0.931</td>
</tr>
<tr>
<td>2) Odd &amp; Even Method</td>
<td>0.943</td>
<td>0.971</td>
</tr>
</tbody>
</table>

The above high values (> 0.900) indicate that the scale maintains an internal consistency over time and is capable of obtaining the same score from the same teacher at different administration (given the same conditions). Hence the investigator establishes that the Science Teachers’ Instructional Preference Analysis Scale is a reliable tool to analyse the instructional preferences of the science teacher in the present educational scenario.

### Validity

Validity is the extent to which a tool measures what it claims to measure. It is vital for a tool to be valid in order for the results to be accurately applied and interpreted. Hence, validity is arguably the most important criteria for the quality of a tool. For a tool to be valid, it must be reliable. The following types of validity were analysed for the developed Science Teachers’ Instructional Preference Analysis Scale.

(a) **Content Validity**

Content validity concerns, primarily, the adequacy with which the test items adequately and representatively sample the content area to be measured. The preliminary draft of The Science Teachers’ Instructional Preference Analysis Scale was given to experts in the field of science education (high school science teachers and teacher educators) to establish its content validity. Discussions were made regarding the statements included under the ten selected categories. Accordingly, modifications were done before finalizing the tool and its administration. Hence, the Science Teachers’ Instructional Preference Analysis Scale possesses content validity.
validity as the statements were selected based on the 92% unanimity of experts on content adequacy, conceptualization and distribution of statements over the ten teacher categories.

(b) Item validity

The items for the final scale were selected by item total analysis and taking the ‘t’ values of the items which had a significance of 0.05 level or higher. The reliability value of the scale if each item deleted was computed and the 53 questions were finalized.

(c) Intrinsic Validity

The scale possesses intrinsic validity since the index of reliability was taken as the intrinsic validity by working out the square roots of the reliability coefficients of the scale. The validity scores of the final scale were obtained as 0.931, 0.965 and 0.985.

The following table 4.10 shows the validity statistics of the final Science Teachers’ Instructional Preference Analysis Scale (STIPAS) having 53 items.

<table>
<thead>
<tr>
<th>Table 4.10 : Validity of the final form of STIPAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Validity</td>
</tr>
<tr>
<td>Cronbach's Alpha</td>
</tr>
<tr>
<td>1) 1st half Vs 2nd half</td>
</tr>
<tr>
<td>2) Odd &amp; Even Method</td>
</tr>
</tbody>
</table>

*intrinsic validity = square root of Reliability Index

The above validity indices indicate that the developed Science Teachers’ Instructional Preference Analysis Scale is a valid tool to analyze the various instructional preferences of science teachers in the present educational scenario. The mean and standard deviation of the final scale were 232.77 & 23.812
respectively. The standard error of measurement of the final scale was computed and found to be low (5.69), which further indicate the high reliability of STIPAS.

It is thus established that Science Teachers’ Instructional Preference Analysis Scale (STIPAS) is a valid and reliable tool conducive for the present study which would give valid scores to analyze the instructional preferences of the secondary school science teachers.

**SAMPLING**

**(a) Population**

The population of the study was identified as the secondary school students of Kerala attending standards VIII, IX and X and the science teachers teaching them. Since schools generally discourage testing in standard X, the investigator was forced to exclude students of standard X. Hence, she decided to confine the sample of students to standards VIII and IX. But, the impact of standard X was indirectly applied to the study by conducting all the testing for the same set of students towards the end of an academic year, based on the assumption that the exit behaviour/learning at the end of an academic year is comparable with the entry behaviour/ learning at the next higher class. Thus, the exit level performance of standard IX could be treated as the entry level performance of standard X students. The investigator, therefore, decided to select the sample for the study from:

- a) the population of standard VIII and IX students of Kerala.
- b) the population of secondary school science (physics/ chemistry/ biology) teachers.

**(b) Sample**

“A good sample of a population is the one which will reproduce the characteristics of the population with great accuracy”. (Cornell, 1960). The educational research studies of similar nature are to be conducted on cluster sampling with classroom as the unit of testing. The sampling technique used for the
study was stratified random cluster sampling technique, so as to ensure representation in selecting a sample from a population composed of subgroups or strata. Due consideration was given to draw the sample on the basis of (i) topographical features like coastal area, high-range area, mid-land area (ii) southern, northern and central regions and (iii) educationally forward and backward districts of Kerala. Accordingly, the sample was drawn from the secondary schools of the following districts of Kerala: Thiruvananthapuram, Kollam, Alappuzha, Ernakulam, Idukki and Malappuram, giving adequate representations to the select demographic variables (gender of the students, location of the school and school management). The secondary school science teachers’ sample was drawn from the same schools. The anticipated sample consists of 757 secondary school students of standards VIII and IX and 116 secondary school science teachers of Kerala.

(c) Administration of tools

In order to collect data regarding the objectives of the study, the tools CVS, SPROSES were administered on the same sample of secondary school students. The investigator contacted the authorities of the selected schools well in advance and explained the purpose of the study, the time required for the administration of the tools and the nature of help required from the school authorities. The school authorities collaborated fully with the investigator and made necessary arrangements for the administration of the tools. The authorities agreed to the supervisor’s request to share the data relating to the achievement in science of the student sample in the final examination, for the purpose of the study. Besides the investigator, the schools made available the services of the class teacher/ science teacher during testing so as to prevent mutual consultation or copying among students. Each of the tools was estimated to take duration of 40 minutes. In order to avoid the element of fatigue and lack of interest, the two tools were administered on two different days. The response sheets of a tool were collected and each sheet was assigned a serial number. The response sheets of the other
tools were collected and arranged on the basis of this serial number on subsequent administration of the other tool. This arrangement helped the investigator to look for the availability of three sets of data from each student, (CVS score, SPROSES score, achievement score) based on the serial number. Only those students whose three sets of data were completely available were included in the final sample of students. Incomplete response sheets were considered faulty and ignored. Accordingly, response sheets from 41 students were not adequate for the study. The data pertaining to all the three scores were available from 716 secondary school students, and they constitute the final sample of students. The teachers’ tool, STIPAS was also administered on the secondary science teachers of the same schools. It was found that a few of the science teachers were hesitant to respond to the tool, stating mere excuses. A few of them failed to respond to all the statements and were hence ignored. The data collected from 103 secondary science teachers were found adequate for the study, and they constitute the final teacher sample. The list of schools and the breakup of the student sample is given in appendix viii.

(d) Scoring

(i) Science Teachers’ Instructional Preference Analysis Scale

The statements included in STIPAS were scored giving weightage to each of the alternate response of the statement in the pattern given below for all the positive statements.

- a- Always 5
- b- Often 4
- c- Sometimes 3
- d- Seldom 2
- e- Never 1

For all the negative statements of the scale, scoring was reversed ranging from 1 to 5. The sum of the scores was taken as the science teacher instructional preference measure. The scores obtained for statements pertaining to each science teacher
preference category, as indicated in the appendix vii (b) were determined and tabulated as the score for that category. The information regarding teacher related variables (teaching experience, number of in-service courses attended in the last two years, rating of the laboratory facilities at school) was also recorded against the score of a science teacher.

(ii) Contextual variable scale (CVS)

The statements included in the Likert Scale were scored giving weightage to each of the alternate response of the statement in the pattern given below for all the positive statements.

<table>
<thead>
<tr>
<th>Response</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>a- Strongly agree</td>
<td>5</td>
</tr>
<tr>
<td>b- Agree</td>
<td>4</td>
</tr>
<tr>
<td>c- Not Sure</td>
<td>3</td>
</tr>
<tr>
<td>d- Disagree</td>
<td>2</td>
</tr>
<tr>
<td>e- Strongly disagree</td>
<td>1</td>
</tr>
</tbody>
</table>

For all the negative statements of the scale, scoring was reversed ranging from 1 to 5. The scores were then tabulated under science instructional, motivational and familial categories according to the assigned serial number. The sum of the scores was taken as the context variable measure. The related demographic information was also recorded.

(iii) Science Process Skill Elicitation Schedule (SPROSES)

The SPROSES was of the multiple choice question type with four alternatives and the students were asked to indicate their response to a test item by putting a cross-mark in the box corresponding to their choice provided in the response sheet. The responses were scored according to the answer key. Each correct response scored one mark while wrong/unattended ones scored zero. The scores pertaining to the basic and integrated science process skills were tabulated separately in accordance with the assigned serial number, on a scoring sheet. The
sum of the basic scores and the integrated scores was taken as the comprehensive science process measure.

(iv) **Achievement in science measures**

In order to focus more attention on the objectives of the study, the scores for the achievement in science were based on the data of the final examination marks, taken from the respective schools as per school records. The final score of the test was converted into grades, based on the following criteria.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Criteria for grading</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>80% to 100% marks</td>
</tr>
<tr>
<td>B</td>
<td>60% to 79%</td>
</tr>
<tr>
<td>C</td>
<td>40% to 59%</td>
</tr>
<tr>
<td>D</td>
<td>Below 40%</td>
</tr>
</tbody>
</table>

Accordingly, the grade obtained was recorded as the achievement in science against each assigned serial number. The decision to convert the raw scores into grades was taken so as to comply with the existing grading system prevalent in the state.

(e) **Consolidated data coding for analysis**

The consolidated data sheet incorporating the context variable score, comprehensive science process measures and achievement grade in science was prepared for each student serial number. The consolidated data sheet for each student is shown in appendix ix. The demographic data relating to a student (like gender, locality of school, school management) was entered against his/her assigned serial number in the same row with proper codes for identification of the details, followed by grade in achievement in science, basic, integrated, total science process measures and the science instructional, motivational, familial and context variable measures. The consolidated data sheet prepared for the tabulation of final data is shown in appendix x.
Methodology

The consolidated data sheet was used for computer processing of data, where the quantified data relating to the different variables were converted into the basic statistical constants (mean, standard deviation, percentages, etc.). The data were also used for computing correlation coefficients, Chi-square Value, etc., and for testing differences between means, differences between coefficients of correlation, etc. as demanded by the objectives of the study.

(f) Statistical Techniques:

The analysis of quantified data was done using the following statistical techniques:

- Tests of significance for difference between means
- Tests of significance for difference between correlations
- Karl Pearson’s coefficient of correlation
- Spearman’s rank correlation coefficient
- Chi-Square test