Chapter III

MATERIALS AND METHODS

This chapter explains, "What was done to solve the research problem: Some correlates of High School Students' understanding of the Nature of Scientific Knowledge". In other words, this chapter has presented the sample, method and the tools used for obtaining raw materials for testing the hypothesis developed in the first chapter.

The sample, materials (Data) and methods (statistical tools) for this research were derived from the three basic research questions:

1. What are the numerical value of Independent Variables i.e. Attitude towards Science, Intelligence, Area of residence (Rural-Urban) and Sex?

2. What is the numerical value of Dependent variables: Understanding of Nature of Scientific knowledge?

3. Are the dependent and Independent variables correlated to each other?

In this chapter firstly sample has been described along with the area of study, the school and the class level. The identifying characteristics of the sample and the justification for sampling have been described. In the second part, the tools used for collecting the data have been described. In the third
part, the materials ie sources, nature and collection of data have been explained. At the end, this chapter has highlighted the statistical devices used for obtaining results ie the treatment and analysis of data.

In this study 'Normative Survey' method has been used. The term 'Survey' suggests the gathering of evidence relating to current conditions. The term 'Normative' implies the determination of normal or typical conditions or practices. Thus an attempt has been made to determine the prevalent practices.

THE SAMPLE
(SELECTION OF THE SAMPLE)

First stage - Selection of sampling area:

For testing the hypothesis developed, the sample needed was of High School science students both male and female. In order to get such a sample, 'Unnao' district of the state of 'Uttar Pradesh' was choosen purposively.

District 'Unnao' was choosen because of following reasons -

1. The Unnao is a backward and 'C' class city of Uttar Pradesh.

2. There were number of boys and girls colleges in the district.
3. It was physically convenient for the investigator to conduct her study in the district 'Unnao' because of her employment.

The Schools:

A list of all boys and girls' High Schools and Intermediate colleges was procured from the office of District Education Officer of the district 'Unnao'. There were 49 schools in the district of Unnao (Appendix A-1). From this list, another list of those schools was drawn which had the facility of instructions of science subject at high school level. 24 schools in Unnao district had the provision of teaching Science at High school level (See Appendix A-2). Seven schools with science teaching facilities were situated in urban area and the rest 17 science teaching schools were functioning in the rural areas of district Unnao. Out of these 24 schools, 14 schools were randomly chosen for data collection for present study. Rural and urban schools were equally represented in the sample of schools (Appendix A-3).

The students:

The sample of present study consisted of rural and urban, High School Science boys and girls, who studied same syllabus prescribed by the 'Board of High School and Intermediate Examination Uttar Pradesh Allahabad; and were prospective candidates for the same High School public examination. Students of High School level were chosen
in the sample of present study due to following reasons:

1. Specialization in science in Uttar Pradesh starts at high school level.

2. The student studying in High School become mature enough to think about their future, to understand the utility and prospects of science, and also its importance in their day-to-day life.

3. In India, where 70% population lies below poverty line, most of the students complete their academic education after secondary stage.

Due to above mentioned reasons High School Science students were thought to be appropriate for the present study.

**Sampling:**

A representative sample of High School science students was selected from amongst those enrolled in the selected schools on random basis. The school-wise distribution of sample has been displayed in appendix (A-4).

Thus the total sample consisted of six hundred and fifty High School Science Students. The area and sex-wise distribution of the sample was as follows (Table no. 3.1)
TABLE 3.1: Area and Sexwise breakup of the sample

<table>
<thead>
<tr>
<th>Area</th>
<th>No. of male students</th>
<th>No. of female students</th>
<th>Total no. of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNNAO URBAN</td>
<td>175</td>
<td>150</td>
<td>325</td>
</tr>
<tr>
<td>UNNAO RURAL</td>
<td>279</td>
<td>46</td>
<td>325</td>
</tr>
<tr>
<td>Total No. of</td>
<td>454</td>
<td>196</td>
<td>650</td>
</tr>
</tbody>
</table>

Characteristics of sample:

**Age** – The mean age of the sampled High School students was 14.6 years.

**Sex** – The girls could be sampled in smaller number as compared to the boys because of poor level of female literacy\(^1\) (12.34\%) in Unnao district, and the schools being very poorly attended by the adolescent girls.

Second Stage – **Selection of Instruments**:

In order to collect the data for the variables of this study (Dependent - Understanding of nature of scientific

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\(^1\)Sankhyaki Patrika 1987, Distt. Unnao Office Statistical Officer, Meaning & Number. State Planning Institute, Uttar Pradesh. p. 50.
knowledge; Independent - Attitude towards science and scientists; and Intelligence), appropriate instruments were chosen from amongst the many that were available.

The instruments were selected on the basis of their merits with regard to:

1. Reliability and validity of the tools
2. Suitability of the tools
3. Time needed for the test
4. Availability and cost of the test.

Following tools were found appropriate for the measurement of variables of present study.

   For measuring understanding of nature of scientific knowledge of rural and urban high school science boys and girls.

2. Attitude towards science and scientists (A. T. S.; Sood, 1975)
   For measuring Attitude towards science and Scientists of rural and urban high school science boys and girls.

3. Intelligence - General mental ability test (Jalota 1973); for measuring intelligence of rural and urban High School science boys and girls.
The general characteristics of the instruments of present study have been presented in Table 3.2.

**TABLE 3.2 : Characteristics of the Instruments**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Name of the Test</th>
<th>Name of the author</th>
<th>Grade</th>
<th>Reliability</th>
<th>Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nature of scientific knowledge scale</td>
<td>Peter Rubba Anthony</td>
<td>High School Students</td>
<td>0.87</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>Attitude towards</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Science and Scientists</td>
<td>Dr. J.K. Sood</td>
<td>For all students</td>
<td>0.76</td>
<td>0.98</td>
</tr>
<tr>
<td>3.</td>
<td>General Mental ability test</td>
<td>Dr. S.Jalota</td>
<td>VII to XI students</td>
<td>0.94</td>
<td>0.78</td>
</tr>
</tbody>
</table>

**Description of the Instruments:**

1. **Selection of Nature of Scientific knowledge scale (N.S.K.S.)**

The investigator has tried to search proper instrument for this study and could spot out only three instruments, out of which two have been used in India and abroad for measuring understanding of the nature of scientific knowledge.

1. **TOUE** — developed by Cooley and Klopfer (1961)
2. **NOSS** — developed by Kimball (1967)
3. **N.S.K.S.** — developed by Peter Anthony Rubba (1977)

The general characteristics of the above mentioned
three tests of measuring understanding of nature of scientific knowledge was reported in Table 3.3

TABLE 3.3 : General characteristics of the test for measuring understanding of nature of scientific knowledge

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Name of the test</th>
<th>Name of the author</th>
<th>Year</th>
<th>Standard</th>
<th>Reliability</th>
<th>Validity</th>
<th>Time limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Test on understanding science</td>
<td>Cooley and Klopfer</td>
<td>1961</td>
<td>7 to 12 grade</td>
<td>Not known</td>
<td>Not known</td>
<td>4.0 minute</td>
</tr>
<tr>
<td>2.</td>
<td>Nature of Science scale</td>
<td>Kimball</td>
<td>1967</td>
<td>For all students teachers and scientists</td>
<td>.54</td>
<td>.29</td>
<td>No time limit</td>
</tr>
<tr>
<td>3.</td>
<td>Nature of Scientific knowledge scale</td>
<td>Peter Anthony Rubba</td>
<td>1977</td>
<td>High School students</td>
<td>0.87</td>
<td>0.80</td>
<td>No time limit</td>
</tr>
</tbody>
</table>

From amongst the above mentioned three scales, Nature of Scientific knowledge scale was selected for the following reasons:

1. This scale has not been used in India and abroad for measuring understanding of scientific knowledge. Therefore this study was designed to experience N.S.K.S. in Indian conditions.

2. The scale was developed to assess the secondary school students' understanding of the nature of scientific
knowledge. The sample of the study was also High School students, that's why it is most appropriate instrument for the present investigation.

3. It was a highly reliable and valid test to assess secondary school students' understanding of the nature of scientific knowledge.

4. It was a recent developed instrument, in comparison to others like TOUS (1961), and NOSS (1967). Hence it was preferentially selected for the present investigation.

5. In comparison to other parallel tools, Understanding of Nature of Scientific knowledge scale consists of appropriate number of items (48). Hence the subject will attempt more willingly.

6. The N.S.K.S. has no prescribed time limit for its administration. This fact was considered useful for the present study.

THE ORIGINAL-N.S.K.S.

The scale was developed by Peter. Anthony Rubba, to assess secondary school students' understanding of the nature of scientific knowledge.

The scale was developed on the first dimension of a Victor Shoulter definition of scientific literacy. The first dimension of Shoulters' definition is:
The Scientific literate person

Understands the Nature of Scientific Knowledge.

The development and field testing took place in seven steps.

1. A Model of the Nature of Scientific Knowledge was developed by the investigator from the literature on the nature and philosophy of science. The model consists of six factors and their implications. Scientific knowledge was characterised as amoral, creative, developmental, parsimonious, testable and unified. Three philosophers of science judged the model's soundness.

2. A five point Likert scale labelled "Strongly agree", "Agree", "Neutral", "Disagree", "Strongly disagree", was selected as the type of instrument, best suited for the measurement purpose. Twelve positive and Twelve negative statements were written for each model factor.

3. Statement reading level was checked with nine-sixth grade students.

4. Ten science educators critiqued the statements for ambiguities and science content generality.

\[\text{Victor Showalter. What is unified science education? (Part 5) Program objectives and scientific literacy. Prima II, Spring, 1974, p.2.}\]
5. The Likert scale was attached to each of the surviving statements which were randomly arranged as a try out instrument. The try out instrument was administered to and critiqued by a group of 31 high school science ability high school students.

6. Seventy-two items were judged content valid against respective model factors by a panel of nine experts.

7. The seventy-two items were tried out with 605 high school students enrolled in five science courses. The most reliable combination of items was identified by calculating mean subscale (one subscale per model factor) coefficient alphas for combinations of items. The four negative and four positive items per subscale with the highest item to subscale score correlation composed the most reliable instrument.

The 48 items were randomly arranged into a Likert instrument entitled the "Nature of Scientific Knowledge Scale." The N.S.K.S. contains six subscales of eight items each, one subscale per model factor.

Reliability of the scale:

N.S.K.S. reliability was studied with a group of High school freshman general science students and a group of High school senior advanced chemistry students using a combination of a four week test-retest and the calculation of coefficient
alpha on each administration. The respective reliability coefficient for the freshmen were 0.59, 0.67 and 0.54, and for the seniors were 0.87, 0.91 and 0.89.

**Validity of the scale:**

Validity of the scale was examined by testing an anticipated difference in understanding of the nature of Scientific Knowledge between a group of 125 college freshmen, who completed a general biology course. No serious difference were found between the two groups. Coefficient alpha for the biology group was 0.80, and for the philosophy of science group was 0.83.

A copy of test is given in appendix B.1

**Adaptation and try out of N.S.K.S. in the Indian conditions:**

For being used in the present study the N.S.K.S. (Rubba, 1977) was translated in Hindi and its reliability and validity was calculated in Indian conditions by the researcher to make the assurance that test which was originally developed in Indian University in 1977, would also be reliable and valid in Indian conditions.

The scale was translated in Hindi because the students may give more accurate answers and understand the questions in their own native language.
The 'Nature of Scientific Knowledge Scale' (Rubba, 1977) was translated in Hindi by the present researcher to make it more fit for the sample under consideration. Every effort was made to obtain a reliable and valid translation of the original scale. For this purpose a team of 25 translators was appointed which included 5 science graduates and post graduates, 5 High School and Intermediate Science teachers, 5 English Teachers, and 5 Research Scholars. The translators were instructed as follows:

"This questionnaire is to be administered on a sample of High School Students. Therefore, while translating the items of questionnaire, from English to the native, Hindi language. A caution to the observed is that simple native Hindi language should be used which may easily be followed by High School students. The basic purpose should be to retain the essential character of the items, making such adjustments as is necessary to fit those into the urban and rural settings. The language formulating the task of the items is not to be translated literally, but the item is to be phrased as such an item would normally be stated for the setting it is being translated:

Specific suggestions for the translators were as following:

1. Use the wording and manner of formulation that is conventional for urban and rural setting.
2. Try to retain the essential character of the item to maximum in order to increase the validity and reliability of the questionnaire.

An appropriate translation was worked out from a number of versions received by the researcher from a team of translators. This translated scale was translated back into English and then was compared with the original scale and the discrepancies were removed. Every effort was made to retain maximum content and face validity. Standard Hindi terminology\(^1\) was used in translation.

In this way a five point Likert type N.S.K.S. in Hindi version was prepared which contained 48 items in which 24 were positive and 24 negative items. The scale continuum laid five points. Strongly agree, agree, Neutral disagree, strongly disagree.

Reliability in Indian condition:

Test-retest reliability of Hindi version of N.S.K.S. (Rubba, 1977) was calculated. For this purpose the instrument was administered on a total sample of one hundred students.

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The scale was readministered on the same sample one month after the first administration of the scale. The Pearson's product moment correlation thus obtained between the scores of the two spaced administrations of the scale was 0.76. It showed that the results yielded by the test would be consistent over time. Thus on the basis of its fair reliability the test was found appropriate for the present study.

TABLE 3.4 : Showing reliability of the original N.S.K.S. and its Hindi Version

<table>
<thead>
<tr>
<th>Original scale reliability ( r )</th>
<th>Reliability of Hindi Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.87</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Validity of the Instrument:

a. Content and Face Validity -

Content and face validity was established by the reactions of the various groups of experts.

b. Concurrent validity of the test -

The original scale of Nature of Scientific Knowledge was used as criterion in validating the Hindi translation. The two scale (original N.S.K.S. and its Hindi Version)
were administered on High School students' of District Unnao and Kanpur who were proficient in English as well as in Hindi Language. One month interval intervened between the two test administration. The measure on the two scale were correlated. Correlation between the original scale and the translated scale in Hindi was found to be 0.94, which is a very high positive correlation. This confirmed that the Hindi translation of the scale measured the same construct as contained in the original scale of Nature of Scientific knowledge.

**Scoring of N.S.K.S:**

The actual Likert technique of assigning each statement a scale value was used. For positive statements, the items were scored as follows:

- Strongly Agree - 5 points
- Agree - 4 points
- Neutral - 3 points
- Disagree - 2 points
- Strongly Disagree - 1 point

For negative statements the items were scored in the opposite order. Thus the highest score will be 240 and the lowest will be 48. The test scores obtained on all the items then measured respondents' understanding of the Nature
of Scientific Knowledge. A copy of Test is given in appendix B.2.

2. Selection of Attitude Scale:

A review of related literature has indicated that very few studies have been conducted in India related to Science attitude. Generally attitude scales used for measuring scientific attitude were based on Likert type or Thurstone type.

NOPP (1935), constructed scientific attitude scale. Similarly scientific attitude inventory was constructed by Moore and Sutman.

A scientific attitude scale was developed by Victor Y. Billeh and George A. Zakhariadas (1975). The scale based on Thurston design. The scale has 24 items, 12 positive and 12 negative. The reliability was calculated by split half method which is 0.55 to 0.74 on Greek public school in Cyprus.

TOSRA, Test of Science related attitude was standardised and develop by J. Fraser (1983), of Macquarie University, Sydney. The Likert type attitude questionnaire containing 70 items for seven different attitude scale.

A standardised test prepared by Sood (1975), for measuring the attitude towards science and scientists.
A brief review given in the table 3.5

### Table 3.5: Showing List of Attitude scales

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Name of the test</th>
<th>Reliability</th>
<th>Validity</th>
<th>No. of Test items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Scientific Attitude Scale by Michael P. Tilford (1973)</td>
<td>0.77</td>
<td>0.80</td>
<td>35</td>
</tr>
<tr>
<td>2.</td>
<td>Scientific Attitude Scale by Victor Y. Billeh and George A. Zakharriadas</td>
<td>0.55 - 0.74</td>
<td>-</td>
<td>24</td>
</tr>
<tr>
<td>3.</td>
<td>Attitude towards Science and Scientists by Sood (1975)</td>
<td>0.76</td>
<td>0.95</td>
<td>100</td>
</tr>
</tbody>
</table>

From among these 'Attitude towards Science and Scientists' by Sood, 1975, was selected for the following reasons.

1. It was easily available to researcher.
2. It could be easily administered because instructions were quite clear.
3. The only available scale which was developed and standardized in India.
4. The items of the scale were in easily understandable language.
5. It was a highly reliable and valid test in comparison to other parallel test.

6. It was a recently developed instrument.

Attitude towards Science and Scientists (Sood, 1975):

In present study a standardized test prepared by Sood (1975), for measuring attitude towards science and scientists was used. This scale has 100 test items, Likert type attitude questionnaire consisting of four areas is Nature of Science, the Scientist, Scientific work and Science and society.

These areas were further divided into sub-areas. The actual Likert technique of assigning each statement, a scale value, was used for this scale. All statements favouring the proportion are to be scored as: Completely agreed-5; Partially agreed-4; Neutral-3; Partially disagreed-2; Completely disagreed-1. For negative statements the items were to be scored in the opposite order.

The test score obtained on all the items, then measured the respondent favourableness or unfavourableness towards the given point of view. The score value of 500 indicates most favourable attitude; of 300, a neutral attitude, and 100 most unfavourable attitude.
Reliability of the Test:

Spearman Brown Formula was used to calculate the reliability of the whole test. The procedure of the split-half method was used to determine the reliability of the test; the reliability was found to be 0.765.

Validity of the Test:

The attitude scale was administered simultaneously with the Test on understanding Science. The purpose was to relate the performance on attitude scale with performance on TOUS (which is standardized and widely used test). Correlation between the attitude scale and the Test on understanding Science was found to be 0.98, which is significant beyond .01 level (Lindquest, 1968). This established the concurrent validity of the Attitude scale.

Scoring procedure:

For positive statements, the items were scored as follows:

- Completely agreed - 5 points
- Partially agreed - 4 points
- Neutral - 3 points
- Partially disagree - 2 points
- Completely disagree - 1 point

For negative statements, the items were scored
<table>
<thead>
<tr>
<th>S.N.</th>
<th>Name of the test</th>
<th>Reliability</th>
<th>Validity</th>
<th>Age group</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>C.I.E., Verbal group test of Intelligence T₃, T₄, C.I.E., Delhi</td>
<td>0.97</td>
<td>0.33-0.56</td>
<td>13-14</td>
<td>35 minutes</td>
</tr>
<tr>
<td>2.</td>
<td>Samuhik Budhi Pariksha by Prayag Mehta</td>
<td>0.93</td>
<td>0.44</td>
<td>12-14</td>
<td>18 minutes</td>
</tr>
<tr>
<td>3.</td>
<td>N.G.T.S. Intelligence Test, Manovigyan Shaia, U.P.</td>
<td>Not known</td>
<td>Not known</td>
<td>Class X-XII</td>
<td>1 Hour</td>
</tr>
<tr>
<td>4.</td>
<td>Test of General Intelligence (V.I.T.) by S.N. Mohisin</td>
<td>0.93</td>
<td>0.95</td>
<td>10-16</td>
<td>25 minutes</td>
</tr>
<tr>
<td>5.</td>
<td>Samanya Mansik Yogyata Pariksha (Test of General Mental Ability) Intelligence by M.C. Joshi</td>
<td>0.88</td>
<td>0.47-0.75</td>
<td>12-19</td>
<td>20 minutes</td>
</tr>
<tr>
<td>6.</td>
<td>Sadasban Mansik Yogyata Pariksha (Group General Mental Ability) S. Jalota</td>
<td>0.94</td>
<td>0.50-0.78</td>
<td>12-16</td>
<td>20 minutes</td>
</tr>
<tr>
<td>7.</td>
<td>Verbal Intelligence Test by Rai Chaudhry Ojha</td>
<td>0.64-0.91</td>
<td>0.35-0.51</td>
<td>13-21</td>
<td>40 minutes</td>
</tr>
</tbody>
</table>
in the opposite order. The test scores obtained on all the items measured the respondents' favourableness or unfavourableness towards the given Psychological object. A copy of test is given in appendix B.3.

Selection of Intelligence Test:

A review of Intelligence tests (Louis L. and Mehta P.H., 1966) given in Table 3.6 revealed that many verbal group tests of intelligence were being used in the Hindi speaking areas of the country. Reliability, validity and other details of the tests are reported in the Table 3.6.

From among these Jalota (1973), test of General Mental Ability was selected for the following reasons—

1. It was easily available and it could be easily administered because instructions were quite clear.

2. It was a highly reliable and comprehensive test of General Mental Ability.

3. As the test has been standardized on the population of school going students of VIII, IX, X and XI of Uttar Pradesh.

4. It could be easily used in Hindi speaking areas.

General Mental Ability Test, (Jalota, 1973):

In the present study Intelligence of the sampled
students’ was measured by the 'Group Mental Ability' Test (GMAT) in Hindi (Jalota, 1973).

The scale was constructed and standardized in 1960 on a school going students of VIII, IX, X and XI classes from various schools and colleges at Banaras. It is a group verbal Intelligence test. It has hundred test items, which has to be answered in the time limit of twenty minutes. It has 'Hindi' as a medium of Instruction. All the test items were divided into seven elements which are 1) Vocabulary-Similaries 2) Vocabulary opposites 3) Number series 4) Classification 5) Best answer 6) Inference 7) Analogies. From these aforesaid elements Ten-Ten items were selected from Vocabulary-Similaries, opposites, Best answers and Inference (because these elements measures abilities with a good deal of overlap) and twenty each for the other three elements of Number series, classification and analogies. Two illustrative items were also selected for each element for demonstration purposes. One of them was presented as a solved example, and other was to be solved by the testee, before he was started on the test paper. In scoring procedure one mark allotted to every correct answer.

The aim of the test was to measure the general mental ability of the students' aging in between 11 to 16 years.

Construction and Standardization:

The test was first published in 1951 as a test booklet.
3/51, when it was administered to 206 students of various classes from VII to XI at Banaras. An Item analysis of 20,600 answers were carried out, and the various items were rearranged according to their objectivity determined order of difficulty. The revised test was published as SAMOCHIKA MANSIKA YOGYATA PARIKSHA 4/51. The test was given to a large unselected sample of 1341 school going students of VIII - IX, X and XI classes from various school and colleges at Banaras. The raw scores obtained from the test were dealing with a normally distributed population. The skewness as obtained from the third moment was only 0.71, and the Kurtosis determined from the fourth moment was only 0.91. Such an excellent normal distribution hoped that the norms developed would be applicable to a wider universe of Hindi speaking students.

Reliability of test:

The proportion of success and failures that is necessary for determining the order of item difficulty was used for finding out the unique value or lower limit for the reliability of a test. The value was found to be +0.938.

Validity of the test:

Validity of the test was found by calculating with the criteria of school examination marks. These values ranged from +.50 to +.78. A copy of test is given in appendix B.4.
Preparation for data collection:

The sampled urban schools were contacted personally during Oct. 1984, to make them aware of data collection regarding the research work. The permission of District Inspectors of Schools had been taken and he had also been requested to write the letters to the sampled Institution (List given by the researcher) of the district to cooperate in the collection of Data. The sampled rural schools were contacted through mail, and requested to supply the information regarding the number of science students sex-wise class wise and subject wise. The sampled schools of urban area were contacted personally by the researcher to collect the preliminary information regarding High School Science students.

In this way, with the co-operation of Principal and Head Master, Education Officers of the District, and the efforts of researcher facilitated the process of data collection. Before collecting data, the purpose of research was told to the Head of the Institution. The Heads were also asked to provide teachers for help in data collection.

Administration of Tests:

For obtaining the raw scores, the tests were administered in last of November 1984, in the sampled Institutions of District Unnao (rural and urban). Firstly
the Test of Nature of Scientific knowledge was administered then after the scale of Attitude towards science and lastly the Intelligence Scale. Order of tests given was kept same in all the schools so that the responses may not differ.

**Nature of Scientific Knowledge Scale:**

In obtaining the raw scores of understanding of the nature of Scientific knowledge, N.S.K.S. (Hindi version [7]) (Rubin 1977), was administered. The test was in a booklet form. The answers of the questions were given on the answer sheet prescribed for the purpose.

The investigator saw first that the testees were seated carefully and had their pen or pencils for writing and then started her work in the class with a brief introduction on testing. This helped to establish rapport with the testees, which in turn stimulated them to give free and full expression of their abilities. The answer sheets were distributed to testees giving one to each. The testees were asked to fill up the preliminaries given on the top of the answer sheets. As soon as preliminaries were completed test booklets were distributed. After the completion of distribution, the booklet were opened and directions given therein were read out to examinees. This was followed by explaining the example given for practice. The investigator
insured that all the testees checked the answer given on the answer sheets and that no writing work was to be done on the test booklets; they were asked to start their work.

The investigator took frequent rounds in the class to ensure that there were no attempts to copy from neighbours and also to see that testees did not have any difficulties in the procedure of answering. As soon as they were completed the work, the test booklets and answer sheets were collected.

**Attitude towards Science:**

In obtaining the raw scores of Attitude towards science, The Sood's, 1975 "Attitude towards Science and Scientists" was administered.

Before the test was given the students were told the purpose of giving the scale. The rapport was established. The students were told that the following statements given in the test are concerned with the Nature of Science, Scientists; Scientific work; and Science and Society. The answer sheets were distributed. After filling preliminaries the booklets were provided. The directions given there in, were read out to the examinees. The test needed 40 minute to finish all 100 items.
As soon as 30 minutes were completed; it was announced '10 minutes more' as per instruction of the author of the test. All the test booklets and answer sheets were collected after 40 minutes. No extra time was allowed.

Intelligence Scale:

To obtain the raw scores of High School Science students on Intelligence scale Jalota's (1973), General Mental Ability Test was administered.

The students were comfortably seated in properly lighted and ventilated class room. This was followed by the distribution of the test booklets and answer sheets. The students were asked to write the preliminaries on the answer sheet provided to them. After this Instructions printed on the first page were read aloud with a view to ascertaining that the statements have followed them clearly. Once it was confirmed that the students have clearly understood the instructions, they were asked to commence answer the questions. The total time allowed for this purpose was 20 minutes. This limit was strictly adhered. To and every care was taken to maintain silence and discipline in the class and avoid chances of mutual consultation and copying. When the time was over, the answer sheets and booklets were collected from students.

Scoring of the Answer Sheet:

Scoring of all the three types of answer sheet was
done by the researcher according to the instructions given in the test manuals.

**Scoring of N.S.K.S.**

N.S.K.S. had total 48 items in which 24 items were positive and 24 were negative items. For positive items scoring was 5, 4, 3, 2, 1 for Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree respectively, while for negative items the scoring was 1, 2, 3, 4, 5 for strongly Agree, Agree, Neutral, Disagree and Strongly disagree.

Thus the highest score obtained will be = 240 and the lowest score will be = 48.

**Scoring of A.T.S. Scale**

Attitude scale had total 100 items. For positive statements the items were scored as follows:

- Completely agreed - 5 points
- Partially agreed - 4 points
- Neutral - 3 points
- Partially disagreed - 2 points
- Completely disagreed - 1 point

For negative statements, the items were scored in the opposite order.
Scoring of Intelligence Test:

All the answer sheets were scored with the help of the scoring stencil key. All the correct answers were thickened, counted and one mark for each correct answer was given.

Data Sheet:

The data sheets having raw scores of Nature of Scientific Knowledge; their Attitude towards science and scientists i.e. favourableness or unfavourableness towards the given psychological object and Intelligence were prepared. (Appendix C).

Methods followed for Analysis of Data:

One way analysis of variance and co-variance followed by the determination of correlation coefficient of the scores on dependent variable with each of the two-Independent variables were separately worked out. Details of the statistical Formula have been displayed in Appendix D.