CHAPTER 1

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"Understanding of fundamentals makes a subject more comprehensible; it increases retention in learning; helps for transfer of training; and it narrows the gap between advanced knowledge and the 'elementary' knowledge."

(Jerome S. Bruner, 1960)

Rightly, the Science education without the development of understanding of fundamentals can not lead the students to the intrinsic goals of Science teaching. Therefore an inquiry into the pupils' understanding of the Scientific knowledge need to be thoroughly made before attempting to develop favourable Scientific attitudes and to enhance the level of pupils' achievement in Science. Present study was undertaken to investigate this issue and to suggest ways and means to the Educational Planners for improving the present state of Science education in India.

Nature of Scientific Knowledge: Early Beginnings:

Science education is one of the important aspect of education. In recent years it has been realised that Science is a humanistic culture. Children should learn it to understand various aspects of science which includes concepts,

processes, and understanding of the nature of science. *Learning to Be* (1972), a monumental work on education which has relevance for both developed and developing countries, has emphasized on scientific humanism so that science may be internalized in its proper perspective.

In recent past, school science education has been influenced by various innovative ideas, but in last four decades, changes have come through the improvement of school science programme. Historically speaking, Science Improvements Projects were started in 1953 through the efforts of Man-Power Project at the Columbia Teacher's Training College, U.S.A., and major thrust was given by a group of professional scientists in 1956. A result of this was the establishment of Physical Science Study Committee (P.S.S.C.) which produced materials for Physics teaching and thus P.S.S.C. become the first in a wave of "alphabet" courses to follow. Later on, materials were produced in chemistry and biology etc; both at the national and international level. It will be worthwhile to say that the Nuffield Science Teaching Project (1962) was started in Britain to improve school science teaching. Similarly in India in 1963, Summer Science Institutes were started with the help of U.S.A.I.D. and U.G.C. to re-orient Science teachers for the improvement of Science education at school level. Similar efforts were made in different parts of the country by the Boards of Secondary Education. Similarly the Central Board of Secondary Education improved its Content-cum methodology and structure of science
courses with the help of the National Council of Educational Research and Training (N.C.E.R.T.) and other agencies.

In India, since beginning of formal education, curriculum was in use. The examination conducting bodies prescribed curricula and it was modified from time to time. Major changes occurred after 1947. Since Independence, education was accepted as an instrument to the development of democratic pattern of living. Education was supposed to meet the new social needs as well as aspirations of a free nation. Therefore, Government of India constituted three significant Education Commissions: Radha Krishnan Commission (1948); Secondary Education Commission (1952); Education Commission (1964) to get suggestions for improvement of Education.

**Strengthening Science Education**

Recently, the *Curriculum for Ten Year School: A framework* (1975) has very aptly mentioned the importance of science as School Subject and its relation to life:

"Science is all pervasive, Modern Societies exists on the basis of Science; Science is intimately related to the means of production and means of Communication including Transport. Even Economics and Politics have to depend on Scientific factors such as productivity from land or from Industry . . . . Therefore anyone, in any walk of life must be aware of a certain quantum of Science and technology."
Similarly, The National Policy on Education 1986 has clearly mentioned: 'To develop a national system of Education which envisages a common educational system. The $10 + 2 + 3$ structure of Education has now been accepted mostly in all the parts of our country. In this National System of Education, the study of science will be made compulsory for all.

The above-said educational policy clearly indicates the need and importance of science accepted although. Science either directly or through technology, permeates in every segment of modern human activity. It is involved in everything from those aspects of our lives which we take for granted. The prominence of science gives every individual the need for a science education. The exact extent of this need of course, depends upon one's goals and aspirations. Science plays a large role in our lives. Though, it can be argued that there is a basic literacy level in science that every person needs to possess to be functioning citizen, just as there is an language skills.

The National Curriculum for Primary and Secondary Education - A Framework (1985) has mentioned:

A child will study science for ten years, will acquire observational and analytical skills for self-regulation, ability to use tools, apparatus, instruments and equipment appropriate to his innate and future needs; ability to identify the factors operating in his system and understood their casual relationship, collect, classify, interpret data and make reasonable inferences. He will also understand the basic scientific concepts laws and principles, than apply these in solving problems."

From the above statement it is apparent that Science is being made an essential subject for ten year schooling as it has many advantages to the learner.

Education Commission (1964-66) observed;

"If science is poorly taught and badly learnt, it is little more than burdening the mind with dead information, and could degenerate even into new superstition."

More than two decades have passed since the aforesaid important observations made by the commission but a little and insignificant progress has been done so far to improve the quality of science education. This does not mean to undermine the efforts being made by various agencies like N.C.E.R.T., National Science Education, UNESCO, N.I.E., State Institute of Science and others for the improvement of science education in this country. I mean to say that in addition to these efforts, there is further need of
making efforts in well desired directions and to bring a revolutionary change in various aspects of science education.

As education plunges in decade of 1980s, probably the most serious objective of science education is to develop rationality, humanity and scientific understanding among the individuals. It is truism that development of an understanding of the Nature of Science is most effective answer to the question of 'Knowledge Explosion' in science. In addition to it, there are many advantages to the learner when he develops an understanding of Nature and structure of science, as he has developed numerous manipulative skills associated with Science and technology, and also he uses science concepts, process skills, and values in making everyday decisions as he interacts with other people and his environment.

**Emergence of Problem:**

An analysis of valuable literature on science education has revealed that understanding of the nature of science is essential for all students. Many scientists, educationists, and researchers have presented their points of view for inducing the understanding of the nature of science as one of the main component of developing curriculum. Bruner (1960), Kimball (1968), Pella (1966), are the advocates of the development of understanding of the nature of science.
In India, educational research has been analyzed by Adaval (1968), Ahluwalia (1973), and Bush (1974). All have induced science education in their review as its integral part.

Wilson (1953), concluded that there was a considerable lack of understanding of the nature of science among science students. Allen Jr. (1959), while studying the attitudes of high school seniors towards science and scientific careers found that "Many scientists do not understand the nature of science".

Trent and Crumb (1945), determined understanding of the scientific enterprise outcome with students in PSSC and traditional courses. Trent found that there was no significant difference between the groups. On the other hand, Crumb found that students in PSSC classes showed a greater gain in understanding of science over the school year than the students in traditional courses.

Muller (1963), compared the abilities of secondary school teachers and students of biology in understanding the nature of science, very little difference was shown between the groups.

Studies were conducted by Yager and Wick (1966); Gennaro (1964); and Sovenson (1966), in which BSSC materials were utilized. A multireference approach was found by both Yager and Wick, and Gennaro, to produce greater gains in under-
standing the specific enterprise and critical thinking. Sovenson found that his laboratory centered approach also produced significant changes. Craven (1968), concluded that the college science courses do not develop the understanding of the nature of science.

Ramsay and Howe (1969), raised a significant point:

"The whole area of understanding of Science is enigmatic. It is easy to define when measured by gains in a particular test, but what this really means in terms of generalized understanding of Science, and what the implications are to a teacher, do not seem to be fully clear. It is an area in need of increasing attention from researchers."

Except these some of the important researches in science education have been conducted by National Council of Educational Research and Training; All India Science Teachers' Association; State Institutes of Science Education and the Boards of Secondary Education in different states. There have been research attempt by these agencies in the form of science curriculum, preparing science text books; developing Instructional Materials, and preparing new techniques of evaluation.

In this way while exploring the related literature the investigator did not come across any study in India that has
studied the correlates of Nature of understanding of scientific knowledge. Although understanding of Nature of Science is now considered as one of the main objective of science education. But the information about the research in this particular field was almost negligible.

A decision was therefore taken to carry out a study which studied the High School Students' understanding of Nature of Scientific knowledge and some of its important correlates.

Hence the study, titled as under was undertaken for research:

"SOME CORRELATES OF HIGH SCHOOL STUDENTS' UNDERSTANDING OF NATURE OF SCIENTIFIC KNOWLEDGE".

Variables Under Study:

The related literature lead to a basic question - what are the various factors that contributed towards the better understanding of nature of Science? ?

The answer to this basic question may be either of the three factors classified in three main categories: Personality factors of the learner, Social conditions of the area where child lives and thirdly the formal agencies i.e. school which provide the learning environment to the learner.
Out of many environmental and innate characteristics of the learners the following variables have been chosen for the present investigation.

**Dependent Variable:**

Understanding of Nature of Scientific knowledge.

**Independent Variables:**

1. Attitude towards Science
2. Intelligence
3. Sex
4. Area of residence (Rural-Urban)

**Objectives of the study**

The following were the objectives of the present study.

1. To determine an understanding of the Nature of Scientific knowledge among High School Students,

2. To determine the Attitude towards science among High School students,

3. To investigate whether High School students' understanding of the Nature of scientific knowledge correlated with Attitude towards science in case of the:
   a. Total students
   b. Male students
   c. Female students
d. Rural students

e. Urban students

4. To study the difference in correlation coefficients between understanding of Nature of Scientific knowledge and Attitude towards science of High School boys and girls,

5. To study the difference in correlation coefficient between understanding of Nature of Scientific Knowledge and Attitude towards science of Rural and Urban High School students,

6. To investigate whether high school students' understanding of the Nature of scientific knowledge will correlated with Intelligence in case of the :

   a. Total students

   b. Male students

   c. Female students

   d. Rural students

   e. Urban students

7. To study the difference in correlation coefficients between understanding of Nature of scientific knowledge and Intelligence of High school boys and girls, and

8. To study the difference in correlation coefficients between understanding of Nature of Scientific knowledge and Intelligence of Rural and Urban High School students.
To make the work easily understandable the researcher has made hypotheses. As it is well known that null hypotheses is the best hypotheses in the research for not being prejudice on either side, whether the results are positive or negative. Following null hypotheses were made to test the results:

1. High School students do not possess adequate understanding of the Nature of scientific knowledge.
2. High School students do not possess favourable Attitude towards science.
3. High School students' understanding of the Nature of Scientific knowledge will not be positively correlated with their Attitude towards science.
4. High School science boys' understanding of the Nature of scientific knowledge will not be positively correlated with their Attitude towards science.
5. High School Science girls' understanding of the Nature of Scientific Knowledge will not be positively correlated with their Attitude towards science.
6. Rural High School students' Understanding of the Nature of Scientific knowledge will not be positively correlated with their Attitude towards science.
7. Urban High School students' Understanding of the Nature of Scientific knowledge will not be positively correlated with their Attitude towards science.
8. The level of correlation between attitude towards science and understanding of Nature of Scientific Knowledge for High School science boys' will not differ from that obtained for High school science girls.

9. The level of correlation between Attitude towards science and understanding of Nature of Scientific Knowledge for Rural High School students' will not differ from that obtained for Urban High School students'.

10. High School students' understanding of the Nature of Scientific Knowledge will not be positively correlated with their Intelligence.

11. High School science boys' understanding of the Nature of Scientific Knowledge will not be positively correlated with their Intelligence.

12. High School science girls' understanding of the Nature of Scientific Knowledge will not be positively correlated with their Intelligence.

13. Rural High school students' understanding of the Nature of Scientific Knowledge will not be positively correlated with their Intelligence.

14. Urban High School students' understanding of the Nature of Scientific knowledge will not be positively correlated with their Intelligence.

15. The level of correlation between Intelligence and Understanding of the Nature of Scientific Knowledge for High
School Science boys' will not differ from that obtained for High School Science girls'.

16. The level of correlation between Intelligence and Understanding of the Nature of Scientific Knowledge for Rural High School Science students' will not differ from that obtained for Urban High School students'.

Definition of the Terms

1. High School Students:

   The students' studying in class X were considered as High School students. Operationally defined the Students of Class X studying in district Unnao (rural & urban) who appeared at the High School examination conducted by the U.P. Board Examination, 1985 were termed as High School students.

2. Intelligence:

   Intelligence is an important factor that contributes to success in life, even though it does not imply that a person of high intelligence will always be successful person.

   There is no uniformity regarding the definition of intelligence. There are in fact as may definitions as there are writers on the subject.

According to *Encyclopedia of Psychology (1972)*:

"Intelligence denotes an "ability" ie a condition or a complex of conditions for specific types of performance".
E. L. Thorndike (1911) said:

"Intelligence is demonstrable in the ability of the individual to make good responses from the stand point of truth or fact."

Hunt, a professor of Psychology at the University of Illinois defined Intelligence as:

"The techniques that a child acquires for processing information supplied by his senses."

In Wechsler's opinion:

"Intelligence is the aggregate or global capacity of an Individual to act as purposefully, to think rationally and to deal effectively with his environment."

The above stated concepts of Intelligence are the views of different Educationists and Psychologists. But operationally for the purpose of this research, Intelligence meant the Intelligence score shown by the subjects on 'General Mental Ability' Test by Jalota (1973).

Nature of Science:

It is not easy to define nature of science because science defines its own definition. Some of the definitions of science have been discussed here to clear the concept of Nature of Science.
Conant (1951) stated:

"Science is a speculative enterprise"

For a long period science was taken as an accumulation of facts. Later on it was taken as a product and process. Currently, the Nature of Science has been taken three dimensional comprising concepts processes of science and social aspects of science.

Paul W. Hurd (1969) defined Science as follows:

"Facts in themselves simply do not make a Science. A science is not simply an attraction from empirical data, but the intellectual creation often suggested by the data. It is the discovery of order among data that make the science..... Science is an intellectual activity which arises from personal experiences and takes place in the minds of man. It's simply a way of using human Intelligence to achieve a better understanding of nature and nature's law.

For the purpose of this research the definition given by Hurd (1969), was accepted, and the nature of science was taken as a cluster of activities reflecting the processes, concepts and social implications of science.

**Attitude towards Science:**

An Attitude is often defined as a tendency to react favourably or unfavourably towards a designated class of stimuli, such as a national or a racial group, a custom or an
in institution - Allport has defined an attitude as a "Mental and neural state of readinesses, organized through experience exerting a directive or dynamic influence upon the individuals response to all objects with which it is related"

According to Thurston, (1946):

"An attitude is the degree of positive or negative affect associated with some psychological object"

In the field of science education, the term 'Attitude' has many meanings. A majority of studies on 'Attitude' towards science have been concerned with feelings like verses dislike towards science in general or particular. In this study, attitude towards science and scientists reflect feelings (both favourable and unfavourable) concerning science and scientists.

Operationally, for the purpose of this research, attitude towards science meant the scores shown by the subjects on 'Attitude towards science and scientist' a test by Sood (1975).

Scientific knowledge:

Halton defined scientific knowledge in terms of an individual being able to read and comprehend science material of the difficulty found in Scientific American. J. R. Pierce

believed it meant more than being able to read and comprehend certain words. For him scientific knowledge meant also being generally informed in science (N E A Journal, 1963).

Pella¹ (1966) and his colleagues concluded that a scientifically literate individual understands the,

1) interrelationships of science and society
2) ethics that control the scientist in his work
3) Nature of science
4) basic concepts of science
5) differences between science and society and interrelationship of science and the humanities

Showalter, (1974)² and his colleagues described seven dimensions of scientific literacy on the basis of which develop scientific knowledge. The seven dimensions outlined were:

1. The scientifically literate person understands the nature of scientific knowledge.
2. The scientifically literate persons accurately applies appropriate science concepts, principles laws, and theories in interacting with his universe.

3. The scientifically literate person interacts with the various aspects of his universe in a way that is consistent with the values that underlie science.

4. The scientifically literate person understands and appreciate the joint enterprise of science and technology and the interrelationships of these with each other and with other aspects of society.

5. The scientifically literate person has developed a richer, more satisfying and more exciting view of the Universe as a result of his science education and continue to extend this education throughout his life.

6. The scientifically literate person uses processes of science in solving problems, making decisions, and furthering his own understanding of the universe.

7. The scientifically literate person has developed numerous manipulative skills associated with science and technology.

The dimension factors provided Showalter's definition with a degree of specificity not found in other definitions. Showalter viewed each dimension factor as a continuum. In discussing continuum conception Showalter's observed:

"As an individual become more scientifically literate, he or she will understand this fact or at ever increasing levels of sophistication and will be able and motivated to apply this understanding to a greater number and variety of real life situations. "
The first dimension of this concept has been accepted to assess High School Students' understanding of the nature of scientific knowledge (Basis Rubba's Scale, 1977).

In the words of Rubba (1977):

Scientific knowledge is distinguished from other types of knowledge by the processes used to validate it, the processes of scientific inference. Any separation of product and process in science is obviously artificial. This model concentrates on the products of scientific inquiry for two reasons. First it is with the "body of scientific knowledge" and not with the scientific inquiry process itself which laymen most frequently operate. Secondly, it is assumed that if laymen understand the nature of the products of scientific inquiry they possess a sufficient level of understanding of the nature of scientific inquiry process.

For the purpose of this study, the definition given by Rubba (1977) was accepted. Operationally for the purpose of this research, understanding of Nature of Scientific knowledge meant the scores shown by the subjects on 'Nature of Scientific knowledge Scale', of Rubba (1977), who developed his scale on the first dimension of Showalter's definition.

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Rural -

The places covered under the present study which lacked "municipality" and "town area" services and governed by village panchayats were termed as Rural areas; for example, Purwa, Marawan, Patan etc.

Urban -

The places covered under the present study which possessed "Municipality" and "Town area" services were termed as Urban areas for example, UNNAO city.

Need and Significance of the study

John Dewey, (1910) very aptly observed:

"Science teaching has suffered because science has been so frequently presented just as so much ready-made knowledge; so much subject matter of fact and law, rather than the effective method of inquiry into any subject matter"

The aforesaid statement of Dewey (1910) is equally relevant and true in modern India too, as many studies in the area of science education proved the fact that students of different age and grades did not possess an adequate understanding of the nature of scientific knowledge, hence not
achieving the objective of science education. There are many evidences on the basis of which it can be concluded that science teaching in India is a routine type of work and does not help in developing proper understanding of Nature of scientific knowledge, which are expected from the learning and teaching of science. It was also observed that in our schools little attention was paid to any serious improvement and innovation in the teaching of science. Science has been grossly out of date in content as well as in method and approach.

Realising the need of science education, in a National Policy 1985, science has been made a compulsory subject for ten years' schooling so that at the completion of High School Stage this generation may symbolize the necessary knowledge, and the skills needed for effective citizenship. Some researchers have worked in the area of science education. The researches attempted in the area of Science education fall in one of the following categories:

1. Developmental studies
2. Survey studies
3. Test construction/evaluation
4. Different methods of teaching

While exploring the related literature on understanding of Nature of Scientific knowledge Sen Gupta (1963); Baquer (1965); Nayer (1971) and Pathak (1972), made it evident that the students did not posses an understanding of scientific
knowledge. Though the importance and advantages of scientific understanding has been accepted fully and efforts have been made by the various agencies to improve the method and teaching of science education. The question arises - 'What are the causes of not developing proper understanding of Scientific knowledge. Vasantha (1977), in his study revealed that proper development of understanding of scientific knowledge depends upon interaction of several factors and no one factor is sufficient in itself. Most evident factors generally presented in literature were - The non-availability of effective teaching aids, Ineffective reinforcement from the Parents and poor quality of Teaching in schools. Recently, some studies have been conducted at National and International levels highlighting undernoted factors which effect science teaching: School environment, systematic instruction, structured science course, competencies of the teachers' and facilities available in the schools.

Following question can be raised:

'Are we producing scientifically literate citizen in the 13 or 14 years of basic schooling?'

To answer this question, a composite picture of existing school science programmes needs to be evaluated in terms of High School Students' understanding of the Nature of Scientific knowledge.
Such an assessment is a first step which should be taken before any revision of school science programmes.

Another question may arise in the mind of Investigator that whether the science students are simply cramming what is taught in science Classes, or developing deeper understanding of scientific knowledge they are exposed to?

It was thought that if the aim of science education is to prepare a scientifically literate human being, the understanding of scientific knowledge as well as inculcation of attitude towards science should be accepted as a main objective of science education. It is also evident that knowledge aspect in science is important but the relationship of science with society and development of favourable attitude towards science are equally significant. Accepting the significance of favourable attitude in science very recently Encyclopedia of Educational Research (1985) has mentioned:

"The development of positive attitude towards Science has been an exercised goal of most of the curricular development efforts. Since the last 1950's. It was hoped that increasing interest in science would result in increased science enrolments; which in turn would yield a large science work force pool and scientific literate citizen."

Intelligence is also one of the main factor to be directly
associated with understanding of Nature of Scientific Knowledge. Therefore present study geared at getting an idea about the existing condition of High School Students' understanding of Nature of Scientific knowledge and some of its important correlates as – attitude towards science, intelligence, sex, area of residence (rural-urban) etc.

The attempt of investigator is further justified when the review of research on understanding of Nature of Science yielded following observations:

1. Several researches have been conducted on the measurement of understanding of the nature of scientific knowledge.

2. A few studies measured the effectiveness of a particular course in the development of understanding of nature of science.

3. Many studies compared the understanding of the nature of science between groups of students and science teachers.

4. The variables of understanding of nature of science which were considered by the researchers were: background of science teachers in professional as well as academic training, background of students; new course in methodology; difference between new course and traditional one etc.

Thus, the review did not show any study in India and abroad that has studied the correlates of understanding of the
nature of scientific knowledge (while development of understanding of the nature of science is one of the main outcomes of science education and these outcomes should be given proper place in our schools).

The present study was attempted which investigate the understanding of Nature of Scientific knowledge and attitude towards science among High School students, which may highlight on the effectiveness of the efforts done by the various agencies curriculum planners and Teachers.

The study has also significance in investigating some of important correlates of understanding of Nature of Scientific Knowledge, which may likely prove critical to the development of understanding of Nature of Scientific Knowledge. The knowledge aspect in science is important but the understanding of Nature of Science and development of favourable attitude towards science are more significant in achieving the objectives of science education.

The study may also be helpful in giving educational and personal guidance to the High School Students in selecting curricular groupings specially in rural area and in case of female students. Because the female literacy is very poor. The girls are not inspired and motivated to go into science stream.

The study may also helpful in removing wastage and stagnation
The study has specific significance in Indian social context where 70% population is poverty stricken and science has not reached them for the improvement of their living and learning. Finally it was hoped that the findings of present study would reveal some facts which will helpful for the teachers, parents, educational planners and counsellors for developing an adequate understanding among students and thus achieving the main outcome of Science education.

Limitations and Delimitations

(1) This study was delimited to only some important and directly associated correlates of understanding of nature of scientific knowledge ie attitude towards science, Intelligence, sex and Rural-Urban background. Other related variables such as cognitive development, socio-economic-status, Teacher behaviour, classroom situation, college equipment, Teacher professional background etc, could not be included in the study. Although they may also have some kind of relationship with the dependent variable under study.

(2) The population for the study was delimited in terms of field. This study was confined to the Rural and Urban High School and Intermediate colleges of District Unnao of
State of Uttar Pradesh.

(3) Only 650 students (325 rural and 325 urban) could be randomly selected from High School and Intermediate Colleges of District Unnao. A National or regional samples could not be drawn due to the paucity of resources and time.