CHAPTER 2

REVIEW OF THE RELATED LITERATURE
CHAPTER II

REVIEW OF THE RELATED LITERATURE

The review of the literature means of getting to the frontier in a particular field of knowledge. It involves locating, realising, and evaluating reports of earlier studies.

This chapter has been attempted to study the literature related to the problem titled "Some correlates of High School students' understanding of the Nature of scientific knowledge". Relevant research Journals were consulted with the purpose to, find out what the predecessors in this area have already investigated and what are the new areas to be explored. Review was also helpful in avoiding the duplication of work.

This chapter is divided into two sections:

Section A-

Studies related to understanding of the nature of Science

Section B-

Studies related to attitude towards science

SECTION A:

Researches on understanding of the nature of science:

In the present study, the investigator has tried to determine the existing level of information on "Understanding
of scientific knowledge and some of the important correlates of understanding of Nature scientific knowledge. A thorough study of relevant literature indicates that many researches have taken these ideas jointly and many researches have taken them independently. In the present section the researcher has analyzed research separately regarding understanding of nature of scientific knowledge, on the basis of which conclusions have been drawn. The section was further divided into three subsections.

**Studies on differences in Understanding of Nature of Scientific knowledge with respect to various factors:**

Behnke (1961), compared the reactions of science teachers and scientists to various aspects of science and science teaching, and found that two groups can be differentiated on their opinions of the nature of science. She also found that science teachers with extensive science training held opinions closer to the scientists than the less well trained teachers did.

Miller (1963), compared the abilities of secondary school teachers and students of Biology on understanding science and found that a very little difference exists between the two groups. It means that teachers' understanding of science was not significantly higher than the students' understanding.

Cravan (1966), studied teaching of college courses prevailing at that time and concluded "the development of understand-
ing of nature of science among college students does not take place."

Broadhurst (1967), in his study used TOUS Form W to study 108 senior secondary school chemistry students and their teachers in non-Departmental schools in Sydney, and found that "When the scores of all the pupils were compared with all the teachers on the TOUS, teachers' scores were significantly better.

Welch and Pella, (1967), while comparing the knowledge of science processes among students and science teachers, found that the mean score obtained by the sample of science teachers were significantly higher than the mean score obtained by sample of High school students.

Kimball (1968), has compared the understanding of nature of science among science teachers and scientists. For the purpose he prepared a Nature of Science Scale (NOSS). This study revealed that science teachers did not display a different understanding of nature of science than working scientists. Although both groups scored a lower than what had been expected.

Schmidt (1970), in his study used TOUS and concluded that when science teachers were compared with high school science students in grade 7 to 12, although the mean scores on TOUS were considerably above the mean scores of students at the different grade levels. But it has astonished that "sizable group of teachers had less understanding of science than their
An attempt has been made by Nanak Chand (1970), "Understanding the Nature of Science: A comparative study of Four Groups". Where instrument developed by Kimball (1968) has been used. The findings of this study has revealed:

1. There was no significant difference on NOSS between science and non-science students. The C.R. value was not significant for all science students and arts students, but it was significant when all science and commerce students were compared. The reason for this was that bright students opted commerce these days and they were also studying general science in its content.

In different types of schools no significant difference was found between science and non-science students on NOSS. No significant difference was found between science and non-science students on all levels of Socio-Economic status.

2. When science and non-science teachers were compared it was found that there was no significant difference between the science and non-science teachers on NOSS.

3. When science students and Science Teachers were compared, it was concluded that science teachers possessed low understanding of the Nature of Science than the science students.

4. Comparing science students with Non-science teachers, the investigator found that science students scored
more on NOSS than non-science teachers and the difference was significant.

5. Comparison between non-science students and non-science teachers on NOSS revealed that there was no significant difference between them.

Saraswat and Sood (1974), conducted a study to measure the "understanding the Nature of Science: A comparison of science Teachers and Science students", where one hundred science students of eleventh class and fifty science teachers were taken as a sample. Some of the findings were as follows:

1. When teachers were compared with the students, the mean score of teachers (26) on TOUS was higher than the mean score of students (24.7), however, the difference in these mean score was not significant.

2. When the male students were compared with the female students, the mean score of male students (24.5) was slightly higher than the mean score of female students (24.42), however, the difference in these mean scores was not significant.

3. When the relationship between the scores on TOUS and their years of teaching experience was computed it was found that F ratio of the means of different groups of teachers with years of teaching experience ranging from
1 to 6 years was less than 1 which signifies that there was no relationship between TOUS scores and years of teaching experience.

Another study was conducted by Sood (1975), titled "Understanding of the Nature of Science students" where a sample of 300 science students and 200 science teachers were taken. The findings of this study were as follows.

1. The mean score of the total sample, \(N = 500\) on the test on understanding science reflects that it is not as favourable as indicated by a mean score of 30 of the total of test on understanding science.

2. Science students \(N=300\) and their teachers \(N = 200\) indicated that the mean score of science teachers is higher than the mean score of science students. But there is no significant difference as proved by the \(t\) test.

3. This study has discovered many deficiencies, concerning the nature of science. Items, such as, the lack of creative endeavour in science, the dynamic, expanding and on-going nature of scientific enterprise. (Scientists being serious and intelligent people) because these were not correctly answered by the majority of the students and teachers.

Surjeet Kaur (1976), has determined an understanding of
the nature of science about scientists and researchers, and found that:

1. The total sample (N = 200) of Scientists and science teachers show inadequate understanding of the nature of science. But the inadequacy is not too much as proved by the mean which is 69.37 in comparison to the required mean of 87.

2. This study proves that the difference between the scientists Non-Ph. D. Scientists concerning the understanding of the nature of science is not significant. The data proves that while applying 't' test we get a 't' ratio of 0.3381 which is very less than 1.97.

3. While determining the difference between science teachers and prospective science teachers concerning the understanding of nature of science, the difference is not significant. The 't' test shows that the 't' ratio is 1.6 which is less than 1.97.

4. This study proves that there is no significant difference between scientists and science teachers concerning the understanding of science.

Vasantha, A. (1977), in his study titled - "A study of science talent and its correlates" concluded that "Science talent is based on interaction of several factors and no one factor is sufficient in itself. More researches concerning
these factors may help in better ways of identifying talents.

Another study was conducted by Sood (1978), entitled "An Investigation into the understanding of the Nature of Science among the National Science Talent Search Awardees; Science Teachers; and Non-selected N.S.T.S. students". The study highlighted that:

1. It was revealed that the understanding of the total sample (N = 500), of the nature of science was favourable.

2. The mean score of the N.S.T.S. Awardees was much higher than that of the Non-selected N.S.T.S. students. When the difference between the means was tested for significance they had a \( t \) ratio of 10.20 which is higher than 1.96, the value of 0.05 or 0.01 level of significance. Therefore the understanding of the nature of science among the N.S.T.S. Awardees was much better than the non-selected N.S.T.S. students.

3. The N.S.T.S. Awardees had better understanding of the nature of science than the science teachers.

4. There was no significant difference between the non-selected N.S.T.S. students and science teachers, in their understanding of the nature of science.

5. This study has revealed that there are many areas of science education where a sizable part of the sample lack an under-
standing of the nature of science. Hence programme of the science teachers, and curriculum planning needs inclusion of the understanding of the nature of science, as one of the educational objectives.

A study was conducted by Malhotra (1979), entitled "A study of relationship between An understanding of the Nature of Science Among certain Groups of students". The main findings of the study were as follows:

1. The mean score of the total sample (N = 300) on the Nature of Science was not so favourable as indicated by the theoretical mean of the total score on NOSS.

2. The analysis of data has revealed that an understanding of the Nature of Science increases as we go from VIII grade to X grade students.

3. It has also revealed that there was no significant difference regarding the understanding of the Nature of Science at .01 level between science students of X grade and XII grade.

4. No significant difference was found between boys and girls concerning the understanding of the Nature of Science.

5. The investigator has used analysis of variance for determining the differences in depth, and found that there was no significant difference concerning the understanding of the Nature of Science due to sex difference.
a₂ : Studies relating Understanding of Nature of Scientific knowledge to the curricular groupings.

Gennaro (1964), compared two methods of teaching High school Biology - BSCS yellow version and Laboratory Blocks with collateral Reading. A multi-reference approach was found by him to produce greater gain in understanding the scientific enterprise and in critical thinking.

Crump (1965), in his study on the effectiveness of PSSC course against traditional course concluded that students in PSSC classes showed a greater gain in understanding of science over the school year than did students in traditional classes.

Trent (1965), determine understanding of science by comparing the relative effectiveness of the traditional course developed by the PSSC in attaining the objective Understanding of Science as measured on TOUS. He concluded that the PSSC course may not be as adequate and satisfactory in attaining science understanding and its other objectives as claimed by its authors and other supporters.

Jones (1988), used TOUS to find out attainment of understanding about the scientific enterprise, scientists and the aims and methods of science by students in a college Physical Science course in order to determine whether students
who study in general education course, achieved a higher level of science understanding than those who studied in professionally oriented course. He concluded that the University of Tulsa is more effective in increasing students understanding of science through general Education Physical Science course than the professionally oriented course of chemistry and physics.

Mackay (1968), studied "Understanding of the Nature of Science of some Teachers' College students in the Territory of Papua and New Guinea. He used TOUS for his study on students studying science. In addition to the results providing data on the effectiveness of the Teachers' college science course, in developing students' understanding of the nature of science, the performance of the group on the pretest provided as estimate of their level of understanding of the nature of science at the completion of their secondary school science course.

The results of this study suggested that at the end of Grade 10 in Papua and New Guinea, the level of pupils' understanding of the nature of science was at about the same level as Australian pupils' at the end of Grade 6.

Jungwirth (1969), evaluated the effect of B.S.C.S. on the development of understanding scientific inquiry in the process of science. The test population were consisted of
210 secondary school pupils in seven schools who had been taught B.S.C.S. Biology for two years (Ninth and Tenth grade) during the school years of 1965-1967. The teachers were given the training for four weeks. Towards the end of two years' programme specific test designed to test the ability to interpret data and hypotheses formation were administered. The results indicated that the processes of science can be taught at the ninth and tenth grade level, particularly to the pupils of higher I.Q.

MacKay (1971), while measuring understanding of 'Nature of Science among secondary school students' as they study integrated science courses in Form 1 and 4 (Grade 7 to 10) in Australia, by using TOUS, Form W. For this purpose he selected 8 groups at Melbourne metropolitan area, and gave TOUS at the beginning of 1963 school year. The same test was administered to these students at the end of 1963 school year. Changes occurred were analyzed. A brief summary of the results obtained is given below.

1. A higher proportion of the students completed TOUS on the second testing than on the first testing and for some groups, this accounted for as 50 to 60 percent of the increase in mean score on TOUS from first to second testing. Hence there had been a change in the understanding of nature of science by the course of study.

2. Students who offered science in Form 3 and 4 had a better understanding of science than students who had not offered
science studies at these levels.

3. A number of common deficiencies in students' understanding of nature of science were found in different items of the test.

a3: Studies concerning the development of understanding of scientific knowledge.

Klepfer and Cooley (1963), used series of "History of Science cases" to teach for their investigation. Materials drawn from the History of Science was to convey certain important ideas about science and scientists. They found that this type of instruction is definitely effective in increasing students' understanding of science and scientists as measured by the test on understanding science (TOUS).

Kleinman (1965), in his study used TOUS (Form Jy) and concluded that the high ability pupils in the 7th and 8th grades, who had general science teachers that asked critical thinking questions, had a better understanding of science, of scientists, and of the methods of science than the same calibre pupils of teachers who did not ask critical thinking questions.

Oliver (1965), while measuring the effectiveness of the "History of Science Cases' instruction method for improving the students' understanding of science and scientific activity.
Students in experimental classes made significant gains on the TOUS compared to control groups; no significant differences were obtained in achievement of content.

Craven (1966), studied teaching of college courses prevailing at that time and concluded "The development of understanding of nature of science among college students does not take place.

Sovenson (1966), while conducting the study used ESM material and found that his Laboratory centered approach produced significant changes in understanding the scientific enterprise and in critical thinking.

Tisher (1967), attempted to measure an understanding of the nature of science involving 93 secondary school students. For the Australian group it was reported that, over a six month period, no significant change in understanding concerning science occurred.

The findings revealed that age was associated with the greatest attitudinal differences. The younger teacher expressed more positive attitude towards science.

Carey and Stauss (1969), utilized WISP instrument found that a significant increase ( .01 level ) in the understanding of science by prospective science teachers could be attained via a method course, in which the nature of science was emphasized.
Olstad (1969), studied the effect of science teaching method on the understanding of science. This study was conducted at the University of Washington and aimed to determine the effect of background courses and methods of teaching of science on the elementary school science teachers' method and understanding of science and the relationship to the students' understanding of science through their teaching. For this purpose a specially designed course was introduced for elementary school science teachers and they were trained through specific topics which included nature of science, scientific method and attitude, scientific models, science as a social force, inductive and deductive processes as well as more typical considerations of facilities and equipments, curricular materials and evaluation and so forth.

It was found that the course in science methods for elementary school teachers had been able to produce a significant increase in the understanding of science. Another important finding of this study was that there was found no relationship between the content knowledge and the understanding of the nature of science in the elementary school science teachers.

Jungwirth (1972), conducted "A longitudinal study of the development of understanding of science". The purpose of this study was to evaluate the impact of four years B.S.C.S. course on pupils' development of understanding of science as measured by TOUS. In this study "understanding of science"
refers to people achievements on the TOUS. The sample consisted of 9th and 10th grade pupils. The test used was an authorized adoption and translation (Hebrew) of the TOUS (Form W). Findings revealed that there was a significant gain in understanding of science during the first two year period, and again during the second two-year period. The gain during the first period was similar to that of second period.

Tamir (1972), conducted a study on understanding the process of science by students exposed to different science curricula in Israel, with the purpose to evaluate the contribution of new science course based on expository-confirmatory nature towards the achievement of intangible objectives such as understanding the nature and process of science. The Welch-Science process Inventory was selected as an appropriate instrument. It was administered over a population of 3500 students of 200 classes belonging to four types of schools - Urban and Rural, Agricultural and occupation. It was found that BSCC biology course had the greatest impact an understanding the process of science (as measured by SPI).

One of the most famous study conducted by IEA (International Association for the Evaluation of Educational Achievement) and published under the title Science Education in Nineteen Countries (1973) has taken into account that the students' ability with regard to an understanding of the nature and methods of science. Viewing this, a test drawing heavily on the Test on Understanding
of science (TOUS) was prepared and used for this study.

In terms of sample size, the LEA research represents the most comprehensive study ever conducted in the science education. Comber and Keeves (1973), data obtained from Nineteen countries, has reported correlations mostly around .2 to .3 between science interest and total science test score at the population II (14 year old) level. At the population IV level (terminal year of secondary school) the correlations were much higher around .4 to .6. At this level many students in the sample have opted out of science, so that the strengthened relationship between attitudes and achievement is not surprising. This would suggest that the more scientifically able and interested students are the ones who tend to continue in their study of science, the relationship between attitude and ability is substantially weaker.

Conclusions:

The investigator has tried to analyse 32 studies regarding the understanding of the nature of science. These studies have been conducted in different countries with different purposes in mind and on different samples. Some important points emerged from this analysis are as follows:

1. All the studies fall mainly in three categories ie:
   a) Differences with respect to understanding of scientific knowledge ie Teacher-student, Intelligence level, Grade level, Sex, Rural-Urban etc.
b) Related to curricular Groupings,

c) Concerning the development of understanding of nature of scientific knowledge.

2. All researchers have emphasized that understanding of the nature of science should be one of the integral part of object of science teaching.

3. Some of the researchers have compared innovative science curricula with conventional science curricula to determine understanding of the nature of science among the pupils who were using these materials.

4. Some of the investigators have tried to determine: how science teachers understand the nature of science and disseminate it to their pupils or use it in the process of teaching and learning.

5. Some of the researchers have tried to determine the understanding of nature of science among talented students and compared it with average students. They have also tried to find out the effect of extra-curricular activities organized for them.

6. Some of the researchers have tried to find out: How working scientists understand the nature of science and were compared it with average students.

7. Some of the researchers have tried to find out: How working scientists understood the nature of science and
were compared to a group of science teachers.

8. An analysis has indicated there are two important instruments for determining nature of science.
   (i) Nature of Science Scale by Kimball (1968)
   (ii) Test on understanding science (TOUS) by Klopfer

9. It is also revealed that in some of the instruments understanding of the Nature of Science has taken as a part of the total tool.

10. The analysis related to the understanding of the nature of scientific knowledge has clearly indicated that no researchers in India and abroad has studied the correlates of understanding of nature of scientific knowledge. Hence such studies should be the pre-occupation of future researchers on understanding of nature of scientific knowledge.

Section B

Studies related to Attitude towards science

In the present study, the researcher has tried to determine 'some correlates of understanding of scientific knowledge'. In which attitude towards science was considered as one of the important variable. Therefore in this part an attempt has been made to review literature on attitude towards science and
scientists. The section is further divided into two sub sections:

B1  Studies on attitude towards science:

Hugh Allen, Jr. (1959), determine attitudes of selected high school seniors towards science and scientific careers. The population was 3057 seniors at the high school. An attitude scale was developed, which comprised 95 items. The findings of the study revealed:

1. Students possessed attitude favourable to science and the scientific endeavour.

2. Students felt that science and technology have not only enriched society but are essential to its full development.

3. There was no significant difference between the science and non-science group in their attitudes towards scientific enterprise.

Tatra (1962), conducted a study to find out the effect of a supplementary reading programme of selected fiction about the scientist on senior high school students'. One hundred and twenty subjects were selected on the basis of delimitations of intelligence reading score, age, sex and grade level. Two groups of students were formed; one as an experimental and other as controlled group. An attitude scale, entitled "Attitudes of certain High school Seniors towards science and Scientific careers" developed by Hugh Allen Jr. was used to determine the students' idea about the scientist.
PerrOdin (1966), while studying attitudes concerning science on school subjects of 554 students of 4th, 5th and 8th grades. The investigator used a projective type of instrument consisting of twenty sentence fragments intended to stimulate pupils to express feeling related to science.

An analysis of responses to six of the items on the instrument revealed that fourth graders have very favourable attitudes towards science, favourable attitudes reach a peak in the sixth grade, and decline somewhat at the eight grade level. It was also revealed that children consider science to be an important school subject.

Schwirian (1967), studied the characteristics of Elementary teachers related to attitude towards science in Ohio State University with the purpose to ascertain what personal and professional characteristics of elementary science teachers' relationship with the attitude towards science and scientific enterprise. The findings revealed that age was associated with the greatest attitudinal differences. The younger teacher expressed more positive attitude towards science.

Gallagher and Korth (1969), determined attitude towards science of students. The main findings of the study were:

1. Students who took Physics and/or chemistry demonstrate more favourable attitudes towards science than students who took neither of these courses.
2. No significant differences were found in attitudes towards science between students who took Physics and/or chemistry and those who took neither of these courses.

3. Students who took physics and/or chemistry demonstrated favourable attitudes towards science teachers than students who took neither course.

4. When compared to students who took neither course, to those who took physics and/or chemistry demonstrated more favourable attitudes on a semantic Differential scale entitled "myself as a scientist".

5. On the personality dimensions of the scale "Science" "scientist" and "Science teachers" the mean score for all groups of students was lower than the mean score on the evaluation and activity dimensions.

Isserstedt and Schmidt (1971), tried to discover more about the image of science and scientists of a selected group of high ability students. The total number of students were 98.

A twenty four item instrument was developed, with five point response continuum. It was administered as a pre and post summer experience check. A Post-evaluation revealed that the image has not really changed much as the result of summer enrichment programmes.

Lalwani and Sood (1974), tried to measure the attitude of
high school students in science. It was revealed that students taken as a group did possess positive and constructive attitude towards science and scientists.

Sood (1974), "A study of attitude towards science and scientists among various groups of students and teachers in India". The major objectives of the study were (i) to construct an attitude scale so as to measure the differences in attitude towards science and scientists between male and female students and teachers; (ii) to determine the relationship between the students' and teachers' understanding of nature of science; (iii) to find out how far the favourable attitude of teachers helped developing favourable attitude of students (iv) to ascertain how the attitude towards science and scientists was related to the socio-economic background of the students. The major findings of the study were as follows:

1. The sample reflected positive attitude towards science and scientists which was significantly related to understanding of science,

2. The attitudes of students and teachers differed significantly.

3. There was significant difference in attitude towards science and scientists between National Science Talent Search (NSTS) awardees and non selected NSTS students,

4. Sex difference was not significantly related to attitude towards science and scientists,
5. The difference in understanding the nature of science between science teachers and students was not significant, and

6. There was a significant difference between NSTS and non-NSTS students regarding Understanding Science.

Simpson and Oliver (1985) conducted a study "Attitude towards science and achievement profiles of male and female science students in grades six through ten".

The main findings of the study were:

1. Attitude towards science of adolescent students steadily declined from grade six to grade eight.

2. Male exhibited significantly more positive attitude towards science than females.

3. Attitude towards science of all students declined sharply from the beginning to the middle of the year within each grade.

4. AMS scores of the adolescent students in this study declined steadily from grade six to ten.

5. Female students in this study were significantly more highly motivated to achieve in science than their compartments.
B2: Studies on factors affecting attitude towards science:

Claude W. Gatewood (1963), conducted a study to establish whether a specific project sponsored by the University was actually having a specified desirable change in the opinion of high school students towards science and scientists. In order to determine the difference, two groups (a controlled group and experimental) were selected. No significant changes in the opinion towards science and scientists were found.

In their study Brown and Abell (1965), clearly demonstrated that the positive correlation between pupil attitude towards a subject and achievement in that subject was higher for Arithmetic than for spelling, reading or language.

Lowery (1966), conducted a study "Development of attitude measuring instrument for science education" and indicated that the students from an upper socio-economic status had more positive attitude towards science than from middle and lower socio-economic status.

Ormerod (1973), attempted a study to find out the impact of social and subject factors in attitude formation. The investigator developed an attitude scale based upon Likert method. The test was administered on 178 second to fifth year pupils in a mixed grammar school. This study revealed that by the third year of secondary education, attitudes to the social implications of science have emerged. There was sound statistical evidence that
attitudes to the social implications of science were related to the science subject choices of the most able girls.

Gardner (1975), has reviewed most of the researchers done in the field of attitude towards science and scientists. In his final words he has expressed that — much remains to be learned about the factors which influence attitude towards science.

Hason (1985), has conducted a study concerning factors affecting attitude towards science of secondary school students’ in Jordan. Variables of the study were: sex, mother's level of education, Father's level of education, Science hobbies practised; motivation of science teacher, motivation of text book etc. This study has revealed that attitude towards science appear to the significantly to three variables which are concerned with inner motivation. This study has indicated that an important effect on students attitude toward science is significantly related to students perception of his science ability. It was also revealed that fathers' educational level is most crucial variable influencing attitude of male students.

This part has included 7 research studies related to factors affecting attitude towards science and scientists. The review has shown that most of researchers have used an attitude inventory to measure attitudes. The reviewed indicated that the variables taken were — Intelligence, socio-economic-status, Motivation of science teachers, Mother and Fathers level of
education etc. The review also revealed that most of the researchers have taken either science teacher or students as sample for their studies.

Conclusions and Implications for the Present Study:

The analysis of research attempted in this chapter has revealed that an understanding of the nature of science has been taken as an important and indispensable segments of science teaching. But the challenge to science education is 'to bring to the full range of young people a comprehension of the nature of science as an humanistic enterprise'. This task must be accomplished at acceptable level through school science programme. The analysis over all revealed the following significant points:

1. In India limited studies have been conducted on understanding of the nature of science.

2. No researcher as far as investigators' knowledge concerned has attempted to measure the correlates of understanding of nature of scientific knowledge.

3. The most common instrument used for measuring 'understanding of nature of scientific knowledge was TOUS developed by Klopfer and Cooley and NOSS by Kimball (1968).

Thus the investigator has tried to analyse the literature on understanding the nature of science, and concluded that no
such study has been conducted which studied 'some correlates of High School students' understanding of nature of scientific knowledge'.

Since no such work has been done so far. The present research work is quite important and original.

This study has specific relation to Indian Social context where 70% of the population is poverty stricken and of rural background and science has not reached to them for the improvement of their living and learning.

An attempt has been made to arrange all the studies systematically in the following pages:
Studies on differences in understanding of the Nature of Scientific knowledge with respect to various factors

<table>
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<th>S.N.</th>
<th>Names of author</th>
<th>Year of publication</th>
<th>Sample</th>
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<tr>
<td>1.</td>
<td>Behnke, Frances L.</td>
<td>1961</td>
<td>Science students</td>
<td>There was a considerable lack of understanding of the nature of science among science students</td>
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<tr>
<td>2.</td>
<td>Miller Philip E.</td>
<td>1963</td>
<td>Students of Biology, Secondary Schoolteachers</td>
<td>Very little difference was shown between the groups regarding an understanding of the nature of science</td>
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<td>3.</td>
<td>Craven Gene. F.</td>
<td>1966</td>
<td>College students</td>
<td>Science courses do not develop the understanding of the nature of science.</td>
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<td>4.</td>
<td>Broadhurst N.A.</td>
<td>1967</td>
<td>108 senior secondary school students Teachers non-departmental school in Sydney</td>
<td>Used TOUS. It was found that when the scores of all the pupils were compared with all the teachers on the TOUS, teachers scores were significantly better.</td>
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<td>5.</td>
<td>Welsch W.W. &amp; Pella</td>
<td>1967</td>
<td>Students science teachers</td>
<td>While comparing the knowledge of science processes it was found that mean scores obtained by the sample of science teachers was significantly higher than the mean score obtained by sample of high school students.</td>
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<td>Year</td>
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<td>Kimball N.E.</td>
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<td>Schmidt, D.J.</td>
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| Nanak Chand            | 1968 | Science students, Arts students, commerce students | 1) It was found that there was no significant difference between science and non-science students.  
2) The C.R. value was significant when the science and commerce students compared. |
| Sood and Saraswat      | 1974 | Science teachers, Science students of XI classes | They found that there was no significant difference in the understanding of the nature of science |
| Sood J.K.              | 1975 | Science teachers, Science students | 1. Science students and their teachers indicate that the mean scores of science teachers was higher than the mean scores of science students.  
2. Test on understanding science reflected that it was not as favourable as indicated by mean score. |
<p>| Kaur, Surjeet          | 1975 | Scientists, Non Ph.D. Scientists    | It was found that there was no significance difference in understanding of the nature of science between scientists and non-Ph.D. scientists |
| Sood J.K.              | 1978 | Teachers N.S.T.S. awardees, science teachers, students, Non-selected N.S.T.S. students | It was found that understanding of the nature of science among the N.S.T.S. awardees was much better than the non-selected N.S.T.S. students |</p>
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<td>Malhotra, Reeta</td>
<td>1979</td>
<td>Certain groups of students; Age, sex, grade levels difference.</td>
<td>It was revealed that an understanding of the nature of science increases as we go from VIII grade to X grade students.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2) No significant difference was found between boys and girls.</td>
</tr>
<tr>
<td>No.</td>
<td>Name of author</td>
<td>Year of publication</td>
<td>Sample Description</td>
<td>Findings</td>
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</tr>
<tr>
<td>1.</td>
<td>Miller Philip E.</td>
<td>1963</td>
<td>Students of Biology, Secondary/ school teachers</td>
<td>Very little difference was shown between the groups regarding an understanding of the nature of science</td>
</tr>
<tr>
<td>2.</td>
<td>Gennaro Eugene, D.</td>
<td>1964</td>
<td>Students</td>
<td>A multi reference approach was found by him to produce greater gain in understanding the scientific enterprise and critical thinking.</td>
</tr>
<tr>
<td>3.</td>
<td>Grumb Glenn H.</td>
<td>1965</td>
<td>Students studying PSEE; students in traditional course</td>
<td>Found that the students have a better understanding of science who had science teachers that asked critical thinking questions than the same calibre students of teacher who did not asked critical thinking questions</td>
</tr>
<tr>
<td>4.</td>
<td>Trent John</td>
<td>1965</td>
<td>Students</td>
<td>Found no significance difference between the groups</td>
</tr>
<tr>
<td>5.</td>
<td>Jones, K.M.</td>
<td>1968</td>
<td>University products; products of professionally</td>
<td>He summarised that University products had better understanding of the nature of science than professionally the products of professionally oriented courses.</td>
</tr>
<tr>
<td>6.</td>
<td>Mackey</td>
<td>1968</td>
<td>Secondary school students</td>
<td>It was found that there had been a change in the understanding of the nature of science by the course of study, and a number of common deficiencies in students' understanding of the nature of science were found in different items of test (TOUS).</td>
</tr>
<tr>
<td></td>
<td>Author</td>
<td>Year</td>
<td>Grade Level</td>
<td>Study Description</td>
</tr>
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<tr>
<td>7</td>
<td>Jung Wirth</td>
<td>1969</td>
<td>9th &amp; 10th grades</td>
<td>The results indicate that the processes of science can be taught at the 9th and 10th grade level particularly to the pupils of higher I.Q. level.</td>
</tr>
<tr>
<td>8</td>
<td>Mackay</td>
<td>1971</td>
<td>Secondary school</td>
<td>Students completed TOUS on the second testing them the first testing. Due to this 50 to 60% of the increase in mean score on TOUS from 1st to 2nd testing. It has been a change in the understanding of nature of science by a course of study.</td>
</tr>
</tbody>
</table>
Studies concerning development of understanding of the Nature of Scientific knowledge

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Name of the author</th>
<th>Year of publication</th>
<th>Sample</th>
<th>Findings and suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Klopfer and Colley,</td>
<td>1963</td>
<td>Students</td>
<td>While using the 'History of science' cases in teaching, it was revealed that this method was definitely effective in increasing the students understanding of science and scientists as measured on TOUS.</td>
</tr>
<tr>
<td>2.</td>
<td>Kleinman,</td>
<td>1965</td>
<td>High ability pupils of 7th and 8th grade</td>
<td>Found that students have a better understanding of science, who had science teachers that asked critical thinking questions that the same calibre students of teachers who did not asked critical thinking questions.</td>
</tr>
<tr>
<td>3.</td>
<td>Oliver, M.</td>
<td>1965</td>
<td>Students</td>
<td>Experimental class made significant gain on TOUS than control group. No significant difference in achievement content.</td>
</tr>
<tr>
<td>4.</td>
<td>Craven, Gene, F.</td>
<td>1966</td>
<td>College students</td>
<td>Science courses do not develop the understanding of the nature of science.</td>
</tr>
<tr>
<td>5.</td>
<td>Sovenson L.L.</td>
<td>1966</td>
<td>Students not using B.S.C.S.; students using B.S.C.S. material</td>
<td>Laboratory centered approach produced significant changes in understanding the scientific enterprise and critical thinking</td>
</tr>
<tr>
<td>6.</td>
<td>Tismer R.P.</td>
<td>1967</td>
<td>93 secondary school students Australian group</td>
<td>Over a 6 month period, no significant change in understanding concerning science occurred.</td>
</tr>
<tr>
<td>7.</td>
<td>Carey &amp; Stauses.</td>
<td>1969</td>
<td>Prospective science teachers</td>
<td>Significant increase in the understanding of science among prospective science teachers could be attained by a method course.</td>
</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Participants</td>
<td>Methodology</td>
<td>Findings</td>
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<tr>
<td>8. Roger G. Ostald</td>
<td>1969</td>
<td>Elementary school</td>
<td>Specially prepared course in methods of teaching science has been able to produce a significant understanding of science.</td>
<td></td>
</tr>
<tr>
<td>9. Jungworth</td>
<td>1972</td>
<td>Biology students of 9th and 10th grade</td>
<td>There was a significant gain in understanding of science during the 1st two years period.</td>
<td></td>
</tr>
<tr>
<td>10. Tamir</td>
<td>1972</td>
<td>Students studying conventional course exposed to different science curricula</td>
<td>It was found that B.S.C.S. Biology as compared to CHEM study, chemistry and PSEC Physics had the greatest impact on understanding the process of science.</td>
<td></td>
</tr>
<tr>
<td>11. Comber, and Keeves</td>
<td>1973</td>
<td>Students: Age 14</td>
<td>It was found that population IV level the correlations were much higher around 4 to 6. At this level many students in sample have opted out of science, so that strengthened relationship between attitude and achievement is not surprising. It has suggested the more scientifically able and interested students are the one who tend to continue in their study of science.</td>
<td></td>
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</tbody>
</table>
## Studies on Attitude towards Science

<table>
<thead>
<tr>
<th>S.N.</th>
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<th>Findings and suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hugh Allen Jr.</td>
<td>1959</td>
<td>Students, High School seniors</td>
<td>Students possessed attitudes favourable to science and scientific endeavour</td>
</tr>
</tbody>
</table>
| 2.   | Tatra                       | 1962                | High School students            | The results indicated that the reading of novels which presented a positive image of scientists had a measurable effect on researchers by changing their ideas about the scientists in a positive direction.  
<p>|                              |                     |                                 | 2) There was no significant relationship between intelligence, reading, score, or average grade in science and change in ideas brought about by reading. |
| 3.   | Perrodin                    | 1966                | 554 students of 4th, 5th and 8th grade | It was found that fourth graders have very favourable attitude towards science, favourable reached a peak in the sixth grade and decline somewhat at the eight grade level. |
| 4.   | Schwirian P.M.              | 1967                | Teachers-Elemtary Science teachers | His findings revealed that age is associated with the greater attitudinal differences, the younger teacher express the more positive towards science. |
| 5.   | Gallagher and Korth         | 1969                | Students                        | Students who took physics and/or chemistry demonstrate more favourable attitude towards science than students who took neither of these courses. |</p>
<table>
<thead>
<tr>
<th></th>
<th>Authors</th>
<th>Year</th>
<th>Type of Study</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>Isserstedt and Schmidt, 1971</td>
<td>1971</td>
<td>Selected group of high ability students</td>
<td>A past evaluation revealed that the image of high ability students has not really changed much as the result of summer enrichment programme.</td>
</tr>
<tr>
<td>7.</td>
<td>Lalwani and Sood</td>
<td>1974</td>
<td>Teachers; students</td>
<td>Concluded that the understanding of the nature of science among girl students was much better than the male students.</td>
</tr>
<tr>
<td>8.</td>
<td>Sood J.K.</td>
<td>1974</td>
<td>Teachers; students</td>
<td>It was found that sample reflected positive attitude towards science and scientists which was significantly related to understanding of science.</td>
</tr>
</tbody>
</table>
| 9. | Ronald D. Simpson and Oliver, J.S. | 1985 | 600 Science students of grade six to ten | 1) Attitude towards science of adolescent students steady declined from grade six to grade eight.  
  2) Male exhibited significantly more positive attitude towards science than females. |
### Studies on factors affecting Attitude towards science

<table>
<thead>
<tr>
<th>S.N.</th>
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<th>Year of publication</th>
<th>Sample</th>
<th>Findings and suggestions</th>
</tr>
</thead>
</table>
| 1.   | Glaude W. Gratewood  | 1963                | High School | 1) No significant changes in the opinion towards science and scientists were found on the twenty eight of the items so tested  
2) On three items, a significantly greater change in opinions by the experimental group was noted. |
| 2.   | Lowery               | 1966                | Students | The study revealed that the students from an upper socio-economic-status had more positive attitude towards science than middle or lower socio-economic status. |
| 3.   | Ormerod             | 1973                | 178, IIInd to Vth year pupils | The study concluded that by the third year of secondary education, attitudes to the social implications of science have emerged. |
| 4.   | Gardner             | 1975                | -       | He expressed that - much remains to be learned about the factors which influence attitude towards science. |
| 5.   | Hason O.E.          | 1985                | Secondary school students of Jordan | The study indicated that an important effect on students attitude towards science was significantly related to students perception of his science ability.  
2. Fathers educational level was most crucial variable attitude of male students. |