# Chapter Two

# REVIEW OF RELATED LITERATURE

## 2.0 INTRODUCTION

Review of related literature helps researcher understand the trend of research in a specific area and hence draw implications; substantial as well methodological; for their own research work. There have been many studies conducted with different objectives and methodologies in the field of science education. The investigator has reviewed a total of 76 studies; directly or indirectly relevant; for arriving at the present research problem. The reviewed studies have been divided in three major parts. Part one is again divided in three subparts. The categorization has been done according to the nature of the studies and the objectives with which they were executed.

2.1. Surveys conducted in science education

- 2.1.1. Construction of scientific attitude and aptitude tests
- 2.1.2. Construction of achievement tests
- 2.1.3. Construction of other tests including factors, correlates and predictors of achievement

2.2. Experimental studies conducted in science education

2.3. Studies conducted abroad

## 2.1 SURVEYS CONDUCTED IN SCIENCE EDUCATION

The first ever study conducted on record was construction of scientific aptitude test by Dave (1964). The survey conducted in science education were done with the purpose of studying students attributes and providing standardized tools to be utilized for various objectives. The tests constructed were for scientific attitude, scientific aptitude, achievement in science and correlates of achievement in science. A detailed review of surveys conducted in science education is presented in the following part. The reviews are divided into three subsection:

2.1.1. Construction of scientific attitude and aptitude tests

2.1.2. Construction of achievement tests

2.1.3. Construction of other tests including factors, correlates and predictors of achievement

### 2.1.1 Construction of scientific attitude and aptitude tests

**Dave (1964)** designed a study to measure scientific aptitude of high school students and to help the authorities concerned in selecting and admitting pupils to the science courses at the university level and help in early identification of exceptional science talent. The term 'scientific aptitude' was analyzed in terms of the basic traits viz., (i) scientific comprehension, (ii) mechanical reasoning (iii) numerical ability (iv) space relations and (v) scientific information. In the beginning, 180 items were prepared and administered to two criterion groups consisting of students having high and low scientific aptitudes, selected on the basis of teachers' ratings and achievement in general science test. Chi-square technique was employed and the items which discriminated between the two groups were considered valid. The item difficulty and internal consistency of each valid item was found out by administering the test to 370 S. S. C. class pupils, selected at random from thirteen different schools of five districts of Gujarat state. The final test consisting of 100 items was standardized on a sample of 1218 S. S. C. class pupils selected randomly from thirty-two schools and three coaching classes of seven districts of Gujarat. The time limit for the test item was fifty minutes. The values of the mean, median and standard deviation of the test scores were found to be 28.27, 28.00 and 9.90 respectively. The chi-square test of goodness of fit showed that the scores were normally distributed. The reliability coefficients calculated and analysis of variance methods were .92, .92 and .89 respectively. Content, construct, concurrent, predictive and cross validity coefficients were also compared.

**Venkataramana (1970)** intended to develop an aptitude test battery in science for the pupils studying in class IX. The investigation sought to develop an instrument which would cover the following seven scientific abilities, viz., numerical, spatial, reasoning, mechanical, interrelationship, cause and effect relationship and ability to infer from experimental data. A questionnaire was prepared and administered to science teachers. The pilot form of the test consisted of 153 items in seven sections according to the various abilities listed above. A group of 200 class IX pupils were drawn from five high schools for the tryout. After the pilot form was administered and the scripts scored, the test items were rearranged according to the difficulty level. The final form of the test consisted of 148 items and timed for 120 minutes. It was administered to 2000 pupils studying in class IX in thirty-nine schools of Andhra Pradesh. The selection of the schools was done on the basis of management, place of location (urban/rural) and sex variables.

The coefficients of reliability of the test found by split-half and K-R method were 0.88 and 0.90 respectively. The validity of the tool was established by correlating the scores of the test with the scores obtained by the pupils in the annual science examination and also with the teachers' rating of the pupils. The grade norms and the T score norms were established. Factorial analysis using Thurstone's centroid formula yielded five factors. However, Fruchter's formula indicated the presence of four factors only. The instrument was found to be useful to measure scientific aptitude of the pupils and helpful to the counsellors in giving right type of service to the maladjusted children wherever possible.

**Sharma (1975)** aimed at developing a test for measuring aptitude for biological sciences of school students of higher secondary stage, taking into account the conditions prevailing in the county. In order to identify the areas relevant enough to be included in the biological aptitude test, twenty-five judges consisting of higher secondary biology teachers, university professors of bio-sciences, doctors, agricultural scientists, psychologists and educationists, were asked to select areas on the basis of their importance and relevance from a list of twenty areas. The judges were also asked to add as many additional areas as they thought fit for inclusion in the test. On the basis of hundred percent agreement, the selected six areas were verbal reasoning, numerical reasoning, biological science comprehension, sympathy towards living being, experimental bent and observation and interpretation. Covering these areas, a list of 224 items was prepared. After screening by a group of ten biology teachers 131 items were retained and included in a preliminary form of the test which was administered to 100 students of class IX in two higher secondary schools of Delhi. Item analysis was done by using biserial correlation. Rejecting the items with low values of biserial r, the final form of the test comprised seventy items. The test was then administered to a sample of 500 class IX students of higher secondary schools of Delhi. The distribution of the final scores, when tested for normality, did not depart significantly from normality. Percentile and T-score norms for the test were worked out.

**Ghosh (1986)** studied Scientific Attitude and Aptitude of the Students and of some Determinants of Scientific Aptitude. The main purposes of the study were: (i) to ascertain the aptitude of the students in science with the help of a specially developed scientific aptitude test, (ii) to appraise the extent of scientific attitude of the students with the help of a specially developed attitude test, (iii) to find out the extent of academic motivation of the students with the help of a standardized test, and the SES of the parents of the students with the help of an SES questionnaire, (iv) to find

out sex-wise and strata-wise differences, if any, in the scientific aptitude and scientific attitude of the students, (v) to determine relationship between the scientific aptitude and variables such as scientific attitude and academic motivation of the students, and (vi) to develop a regression equation of the scientific aptitude on the independent variables identified by the researcher. A scientific aptitude test was standardized on 620 boys and girls (just promoted to class IX) reading in 13 schools situated in urban and rural areas in different districts of West Bengal. A scientific attitude test was also developed (N=200). Bhattacharya's Academic Motivation Test, Kuppuswamy's (Urban) and Pareek's (Rural) SES scales were used. Central tendency, variability, ANOVA, correlation, F-test and t-test were used. Some of the major findings were: 1. Urban students did not show better performances in the scientific aptitude test than rural students. 2. Boys did not possess more scientific aptitude than girls. 3. Boys did not possess better scientific attitude than girls. 4. There was a positive relationship between scientific aptitude and scientific attitude; scientific aptitude and academic motivation; and scientific attitude and academic motivation. 5. Scores in the scientific attitude test could be predicted from scores in scientific attitude, academic motivation, and socio-economic status of parents through multiple regression equation. 6. Students having high scientific attitude were superior to those having low scientific attitude with respect to their scientific aptitude. 7. Urban students belonging to the high SES group had more scientific aptitude than urban students belonging to the low SES group. 8. Rural students belonging to the high SES group did not show better scientific attitude than rural students belonging to the low SES group.

**Patel (1997)** studies the scientific attitude and its correlates among secondary school students. The major objectives of the study were: (i) to construct and standardize an instrument to measure scientific attitude of secondary school students, (ii) to measure the scientific attitude of secondary school students of Baroda, (iii) to study the nature of distribution of scientific attitude scores of secondary school students of Baroda, (iv) to study the relationship of scientific scores with SES, achievement in science, general achievement of students, (v) to compare the scientific attitude of students with – a) high, average and low SES students, b) high, average and low science achievers, c) high, average and low general achievers, d) boys and girls and e) rural and urban students. 18 null hypotheses were framed for the study. The tools required were the scientific attitude scale constructed and standardized by the researcher whereas Desai's (1988-87) standardized socio-economic scale was adopted after making required modifications. The sample of 596 students was

drawn by cluster sampling technique. The mean scientific attitude of the students was 257.76. the mean scientific attitude of the girls was more than those of boys. The mean scientific attitude of urban students was more than that of rural students. The mean scientific attitude of urban students was maximum and that of rural students was minimum. The nature of the distribution of scientific attitude of all the five groups viz., the entire sample, the boys, the girls, the urban students and the rural students was platykurtic. There existed a significantly positive correlation of scientific attitude with SES, achievement in science and general achievement of the students.

### 2.1.2 Construction of achievement tests

**Aram et al. (1957)** constructed and standardized achievement tests in English, general science, social studies and mathematics for the middle school stage. Four subject committees drawn from the staff of the various sections of the Vidyalaya worked out the general objectives and key concepts of different subjects. Test items were developed in accordance with these objectives and key concepts. Information about the characteristics of schools in various districts were procured from the District Education Officers. The stratified random sampling procedure was adopted to select schools for the test administration. The science test was prepared in two parallel forms. After preliminary tryout and pretesting, item analysis was carried out. The test was administered to a final sample of 937 students selected randomly from fifteen schools of Coimbatore district. The curricular validity of the test was assured by the procedure adopted in the item selection itself. The split-half reliability was calculated and percentile norms were also prepared.

**Buch (1960)** provided reliable and valid tool to measure pupils' achievements at standard VIII in the following subjects: (i) Gujarati, (ii) English, (iii) history, (iv) geography, (v) arithmetic, (vi) algebra, (vii) geometry and (viii) general science. These tests were based on the syllabi prescribed by the Education Department of the erstwhile Bombay state for the pupils of class VIII, IX and X. two way tables of objectives and contents were prepared to develop items for each test. Tryout studies were conducted for these items to examine their psychometric properties for selecting effective items. Samples for these studies comprised 400 pupils of class VIII selected at random from forty secondary schools of Gujarat. The method of rational equivalence was used for establishing reliability of these tests. The reliability coefficient for the tests developed ranged from .88 to .96. percentile, z score and T score norms were used for validating these tests. No external

criteria were used for validating these tests. Content validity was, however, established for all these tests in the beginning while preparing the blueprint in terms of objectives and contents and relative weights were assigned accordingly.

**Saxena (1960)** developed a standardized test in general science for guidance purposes for pupils who wanted to opt for science. Two parallel forms of the test were drafted and administered to fifty students of classes VII, VIII and IX, randomly selected from the same institution. Results showed that the two drafts were parallel and were suitable for class VIII. The final test was administered to a sample of 2190 students of class VIII which represented the seven educational regions of Uttar Pradesh. The reliability of the test was determined by the method of rational equivalence. Empirical validity and predictive validity of the test were also determined. Percentile norms were calculated and a scale of standard scores was developed. The differences of scores of urban boys, rural boys and urban girls were compared with regard to their achievements in science. It was found that (i) the reliability coefficient of the test by the method of rational equivalence was .88; (ii)the empirical validity coefficient of the test was .46; (iii) the predictive validity coefficient of the test was .57; and (iv) there were significant differences between the attainments of rural and urban boys, and the urban boys and girls in science.

**Gupta's (1962)** aim of the study was to construct and standardize an attainment test in general science in order to identify good, average and weak students. A detailed study of the syllabus of general science was made and 230 items, mostly of multiple choice type were prepared for the first experimental draft in two parallel forms. Tryout of this draft was carried out on a sample of 450 students randomly selected from ten different higher secondary schools of Kanpur. On the basis of discriminating index and difficulty value, 165 items were selected in the second experimental draft. This draft was administered to the students of class VIII and item analysis was again carried out. Thus, 132 fixed answer type and eight free answer type items were included in the final draft. The time limit of the final draft was ninety minutes. This test was administered to 1602 pupils of class VIII randomly selected from both the sexes drawn from twenty-three schools of Uttar Pradesh. Mean, Median and mode of the test scores were computed and were found to be nearly equal. The measures of skewness and kurtosis, and chi-square test showed that the obtained distribution approximated fairly well to the normal curve. Reliability coefficients calculated by split-half method, Spearman-Brown and K-R formulae were found to be .94, .94 and .93

respectively. Construct and predictive validity coefficients of the test were found to be .50 and .59 respectively. Percentile norms were also calculated.

**SIE (Kerala) (1965)** aimed at standardizing an achievement test in general science for grade VIII students of Kerala. Based upon the analysis of content courses and general objectives of science teaching, the test items related to (i) recognition of facts and information, (ii) skill in problem solving, (iii) ability to discover, (iv) ability to reorganize, and (v) skill in manipulation of instruments, were constructed. The test consisted of 156 items – ten completion type, fifty-six multiple choice type, four true or false type, twenty-six matching type, thirty classification type and nineteen pictorial type. The pilot test sample consisted of 500 pupils of grade IX at the beginning of the year. The standardization sample consisted of 915 boys and 485 girls of urban and rural areas of Kerala. The test had a split-half reliability coefficient of 0.67. The concurrent validity coefficient against the criterion of the teacher-made test was found to be 0.83. Standard scores, normalized T-scores and percentile norms were also computed.

**Sheth (1967)** did Construction and Standardization of Achievement Tests in General Science. The purposes were: (i) to provide tests to measure the achievement of pupils of grades V, VI and VII in general science through objective type of tests and (ii) to determine the strength and weakness of pupils from the analysis of the scores. The preliminary drafts of the tests were prepared giving weightage to objectives and topics. The drafts consisted of 238 items for grade V, 267 items for grade VI and 327 items for grade VII. Seven different subtests for all the three grades was separately tried out on a sample of 100 pupils. The data were analysed and modifications were incorporated. Pilot testing was done on 400 pupils of each grade selected randomly. After item analysis, the final tests contained ninty-four items for grade V, 104 items for grade VI, and 109 items for grade VII. The final tests were administered to a sample of 1235 pupils of grade V, 1161 pupils of grade VI and 1564 pupils of grade VII, randomly selected from twenty-one schools of Bombay city and suburbs. Percentile norms, stanine scores, standard scores and T-scored were computed. Reliability of the tests was calculated for each grade by split-half method, Rulon's formula and by the method of rational equivalence. The validity of the tests was established against teachers' ratings and school annual examination marks in general science. It was found that (i) the reliability coefficients of the tests as calculated by the three methods varied from .888 to .985 for grade V, from .894 to .991 for grade VI and from .932 to .985 for grade VII; (ii) the validity coefficients of the tests against teachers' ratings varied from .56 to .89; (iii) the validity coefficients

of the tests against school annual examination marks in general science ranged from .516 to .832; (iv) the predictive validity coefficients for the annual examination marks obtained for the same sample ranged from .56 to .89 and (v) boys were significantly higher in achievement than girls.

**Dash (1967)** standardized a Battery of Achievement Tests. The main objectives were: (i) the construction of an achievement test battery for the middle schools and senior Basic schools of Orissa; (ii) the comparison of the Basic and traditional school students in respect of curricular achievement and (iii) the comparative study of the factor composition of the battery. The variables in the study were school examinations, common formula for correction of scores, method of instruction, correlated teaching, etc. The tests were constructed in Oriya, mathematics, social studies and general science. The battery was prepared to measure knowledge, understanding, application and computational skill. Each test was an independent test. The battery yielded eleven sub-scores, four subject scores and one aggregate score. The sample was drawn from twenty traditional and seventeen Basic schools selected from eight out of thirteen districts of Orissa; the number of students were 880 and 340 respectively. A preliminary item analysis was made before the final administration. The reliability and validity were calculated and factor analysis was carried out. The reliability by split-half, test-retest and Kuder - Richardson methods were found to be high. The concurrent validity of the test was established by taking school marks in the different subjects as the criteria. The construct validity was also found out from the intercorrelations among subtests and from the factor composition of the tests. Separate norms for Basic and traditional schools in terms of percentiles and stanine scores were established. The following were the findings of the study. The mean scores for the traditional schools were more than those for the Basic schools in fourteen cases. In this case of science, the Basic school students generally showed superiority but in all other cases traditional school students showed superiority in performance; values of standard deviation indicated that the Basic school students were comparatively more homogenous. The results of the factor analysis by the centroid method yielded four factors viz., (i) General Scholastic Ability, (ii) Verbal Application, (iii) Mathematical Factor and (iv) Memory. Fifty percent of the variance in case of traditional schools and fifty-one percent variance in case of Basic schools were accounted for by these factors. The analysis of data further revealed no support for the popular belief that the school examinations are only tests of knowledge. It further revealed that the commonly used formula for correcting test scores for guessing had a tendency to overcorrect in ordinary situations. Knowledge and application were separate constructs. Basic schools reduced

the intra-individual differences in respect of educational growth. The validity of the test established against the criterion marks and quantitative judgements of the teachers were .893 and .836 respectively. There was no significant difference between the data obtained from cross validation sample and the standardization sample.

**Rup Prakash (1968)** constructed and standardized an achievement test in Everyday Science. The objective was to construct and standardize an achievement test in everyday science for class VIII in the Punjab and also to construct a scale to assess the attitude of the students towards learning of Science. The test comprised four variables, namely, (i) acquisition of knowledge of scientific principles, facts and terms; (ii) application of principles and knowledge of science in everyday life situations, (iii) ability to classify materials and substances; and (iv) skill in observation and critical thinking. The difficulty and discriminative values of each item were found out. A separate manual of instructions for examiners for the administration and scoring of the test and separate answer sheets for recording the answers were prepared. The norms were based on the sample of 1380 examinees. The scores made by the whole group and the various subgroups (urban, rural, boys', girls', government and non-government schools) approximately were normally distributed. The reliability coefficient of the test was .44. The percentage norms and the z scores for the whole group and various subgroups were computed. The attitude scale was constructed using Thurstone's technique of equal appearing intervals. The final scale consisted of twenty-four items uniformly distributed. The entire scale was a nine-point scale from extremely favourable to extremely unfavourable. The statements endorsed by an individual was the score of the individual. The split-half reliability coefficient of the scale was .80. the scale was administered to a sample of 1120 students who had already taken he achievement test in everyday science. The major findings were: (i) achievement in science and pupils' attitude towards learning of science were positively related; (ii) the pupils in urban areas scored more in science than those in rural areas; (iii) science achievement of pupils from government schools was better than that of pupils from non-government schools; and (iv) the girls scored higher than the boys in science.

**Vanajakshi (1970)** planned to construct achievement tests so that they would be helpful for comparing the attainments of pupils from year to year or from school to school and for diagnosing strengths and weaknesses of the current educational programmes and practices. The investigator analysed the syllabus, textbooks and teaching methods of three non-language subjects, namely social studies, general science and elementary mathematics and compiled a list of objectives for

each subject. Each objective was analysed and defined in terms of learning outcomes. Weightage for different objectives was decided after discussing with experts and experienced subject teachers. The test items were written and administered to 370 students randomly selected from forty schools of Andhra Pradesh. On the basis of the item validity and difficulty value, eighty items for social studies test, eighty items for general science test and sixty items for elementary mathematics test were finally selected. The final tests were administered to 1000 boys and 600 girls of class VII randomly selected from seventy-five schools of Andhra Pradesh. Means, medians, standard deviations and other descriptive statistics for all the tests were calculated for the total sample, boys, and girls, separately. Separate norms for boys and girls were computed. Detailed norms for the entire sample were given in terms of percentile scores, T-scores and letter grades. Reliability coefficient calculated by test-retest method was found to be .914 (social studies), .900 (general science) and .910 (mathematics). The reliability coefficients obtained by split-half and rational equivalence methods were .94 and .90 (social studies), .90 and .90 (general science) and .90 and .91 (mathematics) respectively.

**Bountra (1970)** aimed at constructing and standardizing a battery of objective type tests in physics and chemistry at the high school level and to study its possible use in certain types of educational research. The experimental drafts of tests, one in physics and the other in chemistry, were framed after analyzing the syllabi of the two subjects for classes IX and X in Uttar Pradesh. The objectives covered in the battery were knowledge, application and skills. For item analysis purpose the experimental forms of tests were administered to students selected on stratified random sampling basis. Validity and reliability of tests were calculated. The final forms of tests were administered on 1739 students of class X, from forty-two schools. The sample included both boys and girls from rural and urban areas. Validity of tests were computed by correlating scores with marks obtained by students at the final high school examination of U. P. Board. Reliability coefficients were found out by test-retest, rational equivalence and split-half methods. Standard scores, percentile norms, and stanine norms were calculated. The validity coefficient of the Physics test was found to be 0.596 and that of the Chemistry Test was 0.605. The test-retest reliability coefficient for the Physics Test came to 0.932 and that for the Chemistry Test it was 0.950. The reliability coefficient by rational equivalence method for the Physics Test was 0.84 and that for the Chemistry Test was 0.89. The split-half reliability coefficient for the Physics Test was found to be 0.79 and for the Chemistry Test it was 0.79. The performance of rural students was found to be significantly better

than that of urban students on both Physics Test and Chemistry Test and boys performed significantly better than girls in Chemistry.

**Bhatt (1971)** attempted to prepare state norms for delta class for Gujarati, arithmetic and science. After a careful study of the existing textbooks and subject content in Gujarati, mathematics and science courses for the delta class level, the test items were constructed on the basis of a blue print incorporating weightage to objectives and content areas. After item analysis, the number of items in science test was 105. The test was administered to 2186 pupils, in Bombay and various districts of Gujarat. Stanine, percentile, standard score and T score norms were found out by test-retest method, split-half technique, Rulon's formula and K-R formula. It was found to vary from .92 to .94 for science. The concurrent validity coefficient ranged from .73 to .98 for all the three tests. Against the criterion of school annual examination marks, the validity coefficient was .93 for science. The study revealed that (i) the girls were superior in language while the boys proved superior in mathematics and science; (ii) the achievement levels of both the boys and the girls decreased with the increase in age; and (iii) the achievement levels differed from district to district in Gujarati, mathematics and also in science.

**Mathur (1971)** conducted a study on Predictive Validity of Some Psychological Factors for Success in Science Courses. The objectives of this study were to find the relationship between psychological factors, viz., intelligence, aptitude, ability, interests and personality, and achievement in science and to find out correlations between the various psychological factors. The study was conducted on 352 boys and 269 girls drawn from four urban and four rural schools. They were divided into three groups according to the subject groups – science – mathematics (group I), Science – biology (group II) and humanities (group III). The Jalota's General Mental Ability Test and Nafde's Non-Verbal Test on Intelligence were used alongwith Numerical Ability Test of DAT, the Mechanical Comprehension Test and the Space Relation Test from Sharma's Mechanical Aptitude Test Battery, Chatterji's Non-Language Preference Record and Saxena's Personality Inventory as tools of research. All the scores were converted into T scores and normalized standard scores. Correlation coefficients between psychological tests and secondary examination marks as a whole and science subjects were worked out separately. The study revealed that (i) the Jalota's test measuring general mental ability was found to be a good predictor of achievement in all these groups with highest correlation coefficient of .80 with achievement in general science in group I and lowest of .50 with achievement in physics in group II; (ii) the

Nafde's Test was found to predict achievement in in subjects in group I; (iii) the Numerical Ability Test of DAT was found to predict achievement in three subjects except biology in group II with correlation coefficients varying in the range of .60 to .74 and (iv) the other tests viz., Mechanical Comprehension, Space Relation, Interest Inventory and Personality Inventory were found valid predictors for some of the subjects in the three groups.

**SCERT (1971)** constructed and standardized a science attainment test for students of Standard VIII of Telugu medium. A large number of items were constructed in Telugu based on the science syllabus of Standard VIII of high schools of Andhra Pradesh. Items were also constructed for the new units incorporated in the science syllabus of Standard VIII. These items were tested on a small sample of Standard VIII students. Some of the items were dropped and a few were refined after the preliminary testing. The final version of the test was administered on 1288 boys and 403 girls of Standard VIII from Andhra Pradesh. Boys and girls were selected randomly from the various high schools of Andhra Pradesh. The standardized test consisted of 100 questions. It was divided into two parts. Part I consisted of questions regarding physics and chemistry and Part II consisted of questions regarding zoology and botany. Each part consisted of fifty questions. Each question had four answers and the students were supposed to find the correct answer out of the four answers. The mean scores of Part I for boys and girls were 21.0 and 19.0 respectively. The critical ratio for Part I was 6.33. The average mean scores of Part II for boys and girls were 22.0 and 21.0, respectively. The critical ratio for Part II was 2.83. The mean scores of the complete test for boys and girls were 22.0 and 20.0, respectively. The critical ratio for the complete test was 8.29. The time required for administering the complete test was one hour and seven minutes. Part I required thirty-five minutes and Part II thirty-two minutes. Scoring key was developed. The test could be used as a yardstick to assess the knowledge of Standard VIII boys and girls of Telugu medium regarding their science attainment. Percentile scores were established for boys and girls.

**Singh (1973)** constructed and standardized achievement tests in general science for standards V, VI and VII for children studying through Sindhi medium in greater Bombay. The pre-tryout of the test was administered to a sample of 100 students from each of the standards V, VI and VII. The sample was drawn from schools situated in different localities and included students from all the strata of the society. The tryout form of the test was administered to a random sample of 185 students in each of the standards V, VI and VII. The selection of the items for the final run was based on the specifications of the contents and the difficulty value and discriminating power of

each item. The final form of the test was administered to 410 pupils of standard V, 380 pupils of standard VI and 440 pupils of standard VII. The reliability coefficients computed by different methods for the three tests were as follows: (i) test-retest method – ranging from 0.92 to 0.96; (ii) split-half method – ranging from 0.96 to 0.97; (iii) K-R formula – ranging from 0.86 to 0.90; and (iv) Rulon's formula – ranging from 0.88 to 0.91. The validity of the tests was found to be (i) between 0.94 and 0.98 by correlating test scores with the annual examination marks, and (ii) between 0.88 and 0.93 by correlating test scores with the teachers' rating (rank correlation method). Stanines, percentiles, standard scores and T-scores were worked out.

**Gupta (1974)** aimed at investigating the factorial structure of attainments in physical sciences and mathematics for pupils of higher secondary/ pre-university stage. In the study the descriptive correlational methodology was employed. The sample consisted of 200 students belonging to the state of Haryana. These students had passed the higher secondary or pre-university examination. The sample was drawn from colleges situated at district headquarters and also interior places of the districts. A battery of the following nine tests was developed: (i) Physics Test 1 (facts and technical terms), (ii) Physics Test 2 (Principles and their applications), (iii) Physics Test 3 (numericals), (iv) Chemistry Test 1 (facts, symbols and formulae), (v) Chemistry Test 2 (chemical laws, properties and their applications), (vi) Chemistry Test 3 ( numericals), (vii) Mathematics Test 1 (algebra), (viii) Mathematics Test 2 (trigonometry), (ix) Mathematics Test 3 (geometry). All these tests were having multiple choice items. The number of items in all the tests ranged from thirty to thirty-eight. The split-half reliability coefficients for these tests ranged from 0.78 to 0.95 with a median value of 0.83. The tests were supposed to have content validity. Data were collected and converted to T scores whenever Kolmogorov- Smirnov Test indicated 'not normal' distribution. Data were analysed by employing product-moment correlations, Thurstone's centroid method of factor analysis, and oblique rotation with the method of extended vectors. On perusal of psychologically meaningful factor matrix and the matrix of correlations between the oblique factors, the following factors were discovered : (i) General Mathematical Ability Factor having high loadings on all the three mathematics tests, (ii) General Factors of Scientific Ability having high loadings on all the tests of physics and chemistry; (iii) Symbol and Number Factor having high loading on Physics Test 3 (numericals), Chemistry Test 3 (numericals) and Mathematics Test 1 (algebra); (iv) Deductive Reasoning Factor having high loadings on Physics Test 2 ( principles and their applications) and Chemistry Test 2 (chemical laws, properties and their applications);

and (v) Space Factor having significant loadings on Physics Test 3 (numericals) and Mathematics Test 2 (trigonometry).

**Gyanapragasam (1975)** set-up a question bank of objective tests**.** The main purpose of the project was to set up a question bank as a practical and significant step towards examination reform. Necessity to switch over to objective tests as a better measure of evaluation was felt on the following grounds: (i) Since a large number of questions can be included in an objective test, the syllabus can be covered adequately. (ii) marking is rapid, reproducible and reliable in such a test. For developing questions or items for the bank, objectives of testing were taken to be knowledge, comprehension, application, analysis, synthesis and critical evaluation. Of all the different types of objective test items, multiple choice items with three to five choices were largely developed in this project. Eleven other types of items included the following: multiple completion, master list, statement and reason, true or false statement, matching, filling up blanks, classification, comparison, simple problems, short answer questions, and comprehension passage. Provision was made in the marking scheme for minimizing guessing error. The draft questions were discussed with the staff handling the particular subject and necessary screening was done. Each question then typed on a card and arranged subject-wise in a card filling cabinet. For the sake of tryout, test papers were prepared by selecting questions out of this pool of items and then administered to the pre-university and degree students of science in Loyola College, who formed the sample of the study. Item analysis was carried out. Facility index and discrimination index were found out for each item which would help the teacher to pinpoint the suitable questions in the objective test at the time of selecting them for preparing test papers, in terms of difficulty level, consistency and relevance of the questions and effectivity of the distractors. The most important outcome of the project is the creation of Loyola Chemistry Question Bank. The bank consists of objective type of questions, mostly at the B. Sc. Level, numbering 2983, of which 1847 have already been tested during thirty-eight objective tests that were conducted throughout the project period. The questions have been classified into various topics in the three main branches of chemistry, namely, organic, inorganic and physical.

**Sharma (1975)** compared the achievement of pupils of delta class in general science and mathematics. The institutions selected for the administration of the tests comprised 24 each of the four types of institutions viz. rural, urban, boys' and girls' of the state of Rajasthan. The final form of the test in general science had 149 items and that in mathematics 100 items. The reliability of

the tests was calculated by the application of split-half method on the scores of 200 boys and 200 girls. Guttman formula and Kuder-Richardson-21 formula were used. The coefficients of concurrent and congruent validities of the tests were obtained by correlating test scores with marks of pupils in the annual examination, and also with the ratings of the pupils made by their respective teachers on a predetermined five-point rating scale. The coefficient of correlation was calculated by the application of product-moment correlation technique taking the entire sample of 1708 pupils into consideration. In order to find out the variance in attainment of the different strata of the samples, analysis of variance was used. The study revealed the following: the reliability of the test prepared by the investigator in general science ranged from 0. 91 to 0.93 and the validity coefficients of the test in general science ranged from 0.45 to 0.58. There was a significant difference between the performance of boys and girls on the test in general science and mathematics. The girls were superior to the boys in both the subjects. There was also a significant difference between the performance of the rural and urban population on the test in general science.

**Tewari (1975)** did factorial Analysis of Areas of Attainments in the Science and Mathematics Courses at the High School Level. The study aimed at (i) exploring the psychological linkage among school subjects which required cognitive abilities for achievement and could be variously combined, and (ii) analyzing the correlations among various branches of science and mathematics to uncover the underlying functional unities in terms of which the grouping of subjects at the elective stages might be reconsidered with a side effect as the possibilities of related studies of sets of subjects which might enforce each other by reason of common elements which accounted for the achievement. The following achievement tests were constructed and administered to assess the achievement of students in areas of attainments in the science and mathematics courses at the high school level, (i) arithmetic, (ii) algebra, (iii) geometry, (iv) physics theory, (v) physics practical, (vi) chemistry theory, (vii) chemistry practical, (viii) zoology theory, (ix) zoology practical, (x) botany theory, and (xi) botany practical. The tests were constructed after the tryout of a large number of items and the item analysis. The reliability of the tests was computed by Spearman-Brown formula and Kudar- Richardson method. The skewness of distribution of the test scores was tested with the help of percentile formula. The validity of the tests was taken for the granted as they were the achievement tests. Factor analysis was done by Thurston's centroid method. Medland's method was followed for the estimation of communalities throughout the process of factor analysis. For the better approximation of communalities reiteration was done. Leyard

Tucker's criterion and Burt's empirical formula for standard error of factor loadings together with the Vernon's recommendation were used to test the significance for further extraction of factors. As a result of analysis five factors were extracted, namely, (i) theoretical factor, (ii) Mathematical factor, (iii) Biological Science Factor, (iv) Chemistry – Botany factor, and (v) General Science factor. The investigation revealed that curricular achievement aligned due not only to the innate abilities combining with aptitudes but also due to the imposition of complex functions by training and education upon simpler structures. The investigation brought out that algebra and geometry facilitated learning of various branches of science. The symbolic elements of algebra and figural elements of geometry were found helpful in developing numerical and spatial reasoning.

**Sharma (1976)** constructed and standardized a battery of tests in mathematics and general science for the delta class pupils studying in different parts of Rajasthan. A few subsidiary objectives were as follows: (i) To find out the specific objectives in terms of concepts, understanding, application and skills which were envisaged by the teachers and the curriculum planners for class VIII in mathematics and general science; (ii) to make a comparative study of the syllabi in mathematics and general science in Hindi speaking states; and (iii) to compare the standards of achievement in both the subjects in respect of sex and rural-urban strata of the population and districts of the state. For the pre-tryout of the test, seven pupils (two brilliant, two mediocre and two dull) were selected. For the tryout of the test, 500 pupils from eleven institutions were taken and for the final form of the test 1708 pupils were selected from forty-eight institutions. The reliability of the tests was computed on a sample of 400 pupils (200 boys and 200 girls) by Guttman and Kuder-Richardson formula using split-half method. For the validity of the tests, (i) internal consistency, (ii) content validity, (iii) concurrent validity and (iv) convergent validity were ascertained. The findings of the study were as follows: (i) it was found that the reliability coefficients of the test for general science was 0.918 and the index of reliability was found to be 0.959. The validity coefficients was 0.41. The girls population in the state scored highest in general science as compared to the other strata of the sample, when means were calculated; the urban strata of the sample scored second highest and the boys strata the lowest in comparison with the strata level mean score. (ii) the performance of the pupils in general science was highest in the districts-Sirohi, Sikar and Tonk and the lowest in Bikaner, Udaipur and Bundi districts. (iii) the girls were found to be significantly superior to boys both in general science and mathematics. There was a significant difference (at 0.05 level) between the performance of the rural and the urban population in general science.

**Sali (1977)** constructed and standardized five unit tests in physics for standard VIII for Maharashtra State Board Secondary Schools. The sample for each unit test during the pilot study ranged from 107 to 149 students (both boys and girls) in standard VIII drawn from sixty-six schools in Poona district. Item analysis was carried out. The final form of the study was administered on a sample constituting 6130 students studying in standard VIII of thirty-one schools in Poona district. Norms were developed in the form of percentiles, stanines, Z-scores and T-scores. Reliabilities obtained through K-R 21 ranged between 0.65 and 0.79 for the five unit tests. By stanley's formula, the r's ranged between 0.68 and 0.83. Content validity was determined on the basis of internal consistency of the test. Validity coefficients ranging between 0.69 and 0.80 were obtained when validated against teachers' assessment in terms of ranks.

**Bhola (1978)** measured achievement in Physics and Chemistry**.** The study had the following main objectives: (i) to study the qualitative and quantitative aspects of students' achievement in physics and chemistry of Matriculation Examination conducted by the Board of School Examination, Haryana – both for morning as well as evening sessions; (ii) to analyze the different aspects of question papers contributing to the effectiveness of examinations; and (iii) to compare the question papers set for the morning and evening sessions. The answer scripts of the candidates in chemistry and physics subjects on Matriculation Examination during the year 1970 and 1971 constituted the population. Systematic sampling technique was used. Separate samples were selected for the morning and the evening sessions from the respective population of the two sessions. Four hundred answer sheets were selected from the morning session for each of the two papers and 200 from the evening session for each of the two papers in the year 1970. But in case of year 1971, a total of 950 answer sheets from the morning session for each of the two papers and 450 from the evening session for each of the two papers were selected. The answer scripts of the candidates and question papers were analysed. The quantitative and qualitative aspects of students' achievement in physics and chemistry were analysed on the basis of their performance on individual question items, in terms of number of attempts, percentage of failures, and divisions obtained by the candidates. The general characteristics of the question items such as average score, standard deviation, frequency of the highest score and coefficient of variation were also computed. Appropriateness of question paper was studied on the basis of its format, representation of the contents of the syllabus and realization of the objectives of science teaching. Format included choice of alternatives, possible combination of questions, allocation of marks and forms of the questions. Discrimination power,

difficulty value, reliability and validity of each question were studied. Since the study was concerned with mostly essay type question papers, some unconventional techniques were devised for the analysis of data. In some cases, techniques evolved by Gayen and others were employed. The following were some of the major conclusions of the study: (i) Alternate question papers set for the morning and evening sessions were not analogues and of same standard. (ii) A large number of failures and very few first or second classes indicated the quantity and quality of the achievement in physics and chemistry. (iii) the format of the question paper was poor from the points of content coverage and representation of the objectives of teaching physics and chemistry. (vi) the question papers were not well balanced in respect of attributes of discriminating power; difficulty value, reliability and validity of the question items.

**Chhaya (1978**) studied achievement in Physics of the Students of Class VIII and X. The major objectives of the study were: (i) to make an analytical study of the content in physics in the educational programmes for classes VIII and X of the three school systems; (ii) to construct and standardize an achievement test in physics for classes VIII and X; and (iii) to make a comparative study of the achievement of boys and girls in physics of the schools of three systems. The sample consisted of 1200 students of classes VIII and X selected at random from all the schools belonging to the three school systems located in the four metropolitan cities, namely, Bombay, Delhi, Calcutta and Madras. The tools prepared for the purpose of this investigation were the standardized tests of achievement. The reliability coefficients for the tests of classes VIII and X were 0.903 and 0.897 respectively. The t-test was employed to study the differences between different groups. The major findings of the study were: (i) There was no significant difference between the mean achievement in physics of pupils of class VIII as well as class X belonging to Central Schools and the public schools affiliated to the Central Board of Secondary Education. (ii) the mean achievement in physics of classes VIII as well as X of Central Schools was more than that of the pupils of schools affiliated to the Council of Indian School Certificate Examination. The difference between the two was significant at 0.01 level. (iii) the mean achievement in physics of pupils of classes VIII as well as of X of the public schools affiliated to the Central Board of Secondary Education was significantly more than that of the schools affiliated to the Council of Indian School Certificate Examination.

**Khandelwale (1981)** aimed at constructing and standardizing achievement tests in Physics for Class IX. The tests were based on the syllabus of physics for class IX in Maharashtra. Two sets of

achievement tests were constructed. One set covered first five units of the syllabus and was to be used at the end of the first term. The second was based on the remaining five units of the syllabus and was to be used at the end of the second term. The tests were standardized on the population of the students of Class IX in the secondary schools of the Vidarbha region of Maharashtra. The sample for the tryout of the tests consisted of 200 students drawn from five schools of the region. The sample for the final normative study included 1200 students drawn from thirty-three secondary schools. The tests were based on the prescribed syllabus and covering four objectives, namely, knowledge, understanding, application and skill. A two-dimensional blueprint was prepared giving weightage to different objectives and various subunits of the syllabus. Item analysis was carried out to find out the item statistics. The tests were validated and their reliability was also established. The reliability coefficients using the split half method and Spearman-Brown formula were found to be 0.85 and 0.84 for the two tests. Indices of reliability were also calculated. The test scores were correlated with the examination marks to establish concurrent validity. The coefficients of criterion related validity (concurrent validity) for the two tests were 0.83 and 0.85. Percentile, stanine, Z-score and T-score norms were worked out.

**Raveendranathan (1983)** conducted a Comparative Study of the Impact of Medium of Instruction on the Science Achievement, Science Interest and Mental Health Status of Secondary School Students. The objectives of the study were: (i) to compare the science achievement, science interest and mental health status of secondary pupils in the English medium and Malayalam medium classes, and (ii) to to determine the relationship between the medium of instruction and science achievement, science interest and mental health for the total sample and sub-samples. The main hypothesis was that the pupils studying in the English and Malayalam medium classes differed significantly in their science achievement, science interest and mental health status. The study had a sample of 890 secondary school pupils chosen by the application of stratified random sampling method. The tools used were the Achievement Test in Biology by Chandrika (1981), the Achievement Test in Physical Science by Vimala, the Science Interest Inventory by Muthu Pillai, Mental Health Status Scales by M. Abraham, Raven's Standard Progressive Matrices, and the Socio-Economic Status Scale of Kuppuswamy. The statistical techniques applied included calculation of means and standard deviations, testing the significance of the differences between means, for correlated and uncorrelated groups, and calculation of the point biserial correlation coefficient. The main findings of the study were: 1. Science achievement, science interest and

mental health status of pupils of English medium classes were higher than those of pupils of Malayalam medium classes, 2. Science achievement, science interest and mental health status of pupils of English medium classes were higher than those of pupils of Malayalam medium classes for sub-samples equated on the basis of intelligence, interest and mental health status. 3. For sub-samples equated on the basis of high socio-economic status and high mental status, the differences between English and Malayalam medium classes in science achievement and science interest were not significant.

**Ansari (1984)** constructed and standardized a battery of achievement tests in general science for pupils of classes of V, VI and VII studying through Hindi as medium of instruction in Greater Bombay, (ii) to compare the achievement in science of children studying in municipal and non-municipal schools in the city of Greater Bombay, and (iii) to compare the achievement of boys and girls in science. For standardization of achievement tests, the test items were tried out on different samples. The try-out sample was 1200 students. Item statistics were calculated. The final sample for fixing the norms included 1702 students of class V, 1462 students of class VI and 1391 students of class VII. The norms were expressed in stanines, percentiles and standard scores. The major findings were as follows: 1. The performance of boys was better than that of girls. 2. The students of non-municipal schools had a better performance in general science than those of municipal schools. 3. These findings held good for all the classes, viz., class V, class VI and class VII.

**Ghosh (1985)** studied achievement of the students in chemistry and found relationship with some of its determinants. The main purposes of the study were (i) to appraise the achievement of the students in physical science, (ii) to appraise the extent of academic motivation, intelligence, and socio-economic status of the students, (iii) to find out sex-wise and strata-wise differences, if any, in the achievement in physical science, (iv) to determine relationships among the scores of the Achievement Test in Physical Science, the Intelligence Test, the Academic Motivation Test and the Socio-economic Status Scale, and (v) to develop regression equation of the achievement in science on intelligence academic motivation, and socio-economic status. As achievement test in chemistry was standardized on 450 boys and girls (just promoted to class X) reading in nine schools in West Bengal. Test-retest reliability, content, predictive and concurrent validity and T-score norms were developed. Bhattacharya's Academic Motivation Test and Group Intelligence Test, Kuppuswamy's (Urban) and Pareek's (Rural) SES scale were used along with the achievement test. Mean, SD, ANOVA test, Mann-Whitney U – test, correlation were used. Two

multiple regression equations were developed. Some of the major conclusions were: 1. Urban students did not show better performance in the Achievement Test in Chemistry (ATC) than rural students. 2. Boys did not show superiority in ATC over girls. 3. There was a positive correlation between the scores in ATC and Academic Motivation Test, ATC and Group Intelligence Test, urban and rural students' scores in ATC and 'Income of the Parents', rural students' scores in ATC and 'Education of the Parents' as well as 'Occupation of Parents'. 4. Scores in ATC could be predictive from the scores in Academic Motivation Test, Group Intelligence Test and SES of the parents through multiple regression equation. 5. The ATC was reliable and valid. Norms were also satisfactory.

### 2.1.3 Construction of tests including factors, correlates and predictors of achievement

**Baqer (1965)** investigated differential factors in pupil success in science, arts and commerce courses at the higher secondary stage. The study aimed at finding out whether these existed a differential pattern of factors required for successful performance in the science, arts and commerce courses offered at the higher secondary stage. It was hypothesized that: (i) the respective abilities required for success in the three courses under study will differ and (ii) it is possible to differentiate between the successful candidates of the three courses at the beginning of the three-year course with the help of the ability measures used. The study was designed on a follow up basis. Pupils entering class XI in the three courses viz., science, arts and commerce were studied for a period of three years in order to see which of the factors covered in the present study showed a significant relationship with the ultimate success at the end of class XI when they took a public examination. 364 students in science course, 326 students in arts and 414 students in the commerce course, studying in five large representative urban schools of Delhi, were selected. The predictive battery of Differential Scholastic Aptitude Tests consisting of nine sub-tests, viz., numerical, verbal, inductive reasoning, deductive reasoning, spatial, perceptual speed, finger dexterity, rote memory and physical relations (test – retest reliability coefficients for speed tests ranged from .60 to .75 and for non-speed tests from .82 to .92), Prantiya Shikshan Mahavidyalaya (P. S. M.) Interest Inventory, and the Brown- Holtzman's Survey of Study habits and attitudes were used for data collection. Pass- fail results and annual examination marks were used as criteria of success. Product-moment correlations and biserial correlations were computed and technique od analysis

of variance was employed for analyzing the data. It was observed that the findings supported the hypothesis that the combinations of factors required for success in three courses did show differences both in kind and degree. Thus, while inductive reasoning assumed the greatest importance for the science course, verbal meaning turned out to be the best single predictor for the arts and commerce courses, the magnitude being the highest for the arts course. The second best predictor for science was verbal meaning, for arts numerical facility and for commerce was verbal facility. A combination of two factors in each case seemed to provide the best multiple correlation. As regards the comparative usefulness of the tests included in the battery for predicting academic success, it might be said that out of the eight ability tests only three viz., verbal meaning, inductive reasoning and numerical facility seemed to be important. Study habits and interest, when measured by inventories of the type included in this study did not seem to contribute significantly to the prediction of academic success. With the type of correlations obtained for the three courses, the study suggested that better prediction was possible for those subject areas with which the pupils had longer acquaintance. The study showed that when academic criteria were involved, differential prediction with the help of differential aptitude tests was not a very promising approach. The study causes serious doubt on the assumption made by many counsellors and guidance workers that a significantly higher level of general mental ability was required for success in science course than for success in the arts and commerce courses, at least at the higher secondary stage.

**Jha (1970)** examined the nature of relationship between intelligence, science aptitude, adjustment, anxiety, extraversion, study habits, and socio-economic status on one hand and achievement in science on other hand. Hypotheses tested in the study were: (i) there exists a substantial positive relationship between achievement in science and each of the factors viz., general intelligence, scientific aptitude, adjustment, study habits, and socio-economic status; and (iii) there exists a substantial negative relationship between achievement in science and anxiety and extraversion. A random sample of 342 boys and 104 girls was drawn from two boys' and two girls' schools situated in the same locality with identical features. The Mohsin's General Intelligence Test, the Roy Choudhary's Science Selection Test, the Sinha and Sinha's adjustment Inventory, the Taylor's Manifest Anxiety Scale, the Antarmukhi Bahirmukhi Vyaktitva Prashnavali, the Wrenn's Study Habit Inventory, and Kuppuswamy's Socio-Economic Status Scale were used as tools of research. Achievement in science was measured by having the average of two preceding annual examination marks in science subjects. Statistical analysis was carried out with the help of correlation, chi-

square test, t-test, and Mann-Whitney U test. Following were the findings: (i) there was a significant positive relationship between achievement in science and (a) general intelligence, (b) scientific aptitude and (c) adjustment, (ii) there was a significant negative relationship between achievement in science and anxiety in case of boys and combined samples, but not so in the case of girls, (iii) there was no relationship between achievement in science and extraversion; (iv) there was a significant positive relationship between achievement in science and study habits in the case of boys and combined sample, but not so in the case of girls; and (v) there was no relationship between achievement in science and socio-economic status.

**Nayar (1971)** attempted to predict achievements in science the with the help of following six variables: verbal reasoning ability, numerical ability, comprehension and interpretation, problem solving, critical thinking ability and spatial ability. Factor analysis of the correlation matrix of the above variables was also carried out to study the amount of variance that could be attributed to aptitude for science. The pretesting for conducting item analysis for the tools used was on 370 students (195 boys and 175 girls) studying in standard X in selected schools in Trivandrum revenue district, Kerala. The tools used were: (i) Verbal Reasoning Test of NCERT (VR); (ii) Numerical Ability Test Form A of the Differential Aptitude Test (NA); (iii) adapted version of the Comprehension and Interpretation of the Educational Testing Service Cooperative Science Test Form Y (CI), Part III; (iv) the Problem Solving Test based on the Cooperative Sequential Test of Educational Progress Science Test; (v) adapted version of the Watson-Glasser Critical Thinking Appraisal; and (vi) the revised Minnesota Paper Form Board Test AA (FB) to measure spatial ability. Reliability of these tests were established by test-retest (N=135) and split-half (N=441) methods. Standard errors of measurement of test scores were also calculated. Tests were validated against school marks in science. Predictive validity studies were attempted by following up forty-two students of first year pre-degree classes and 180 of second year pre-degree class taking marks in science as criterion. A stratified sample of 441 students (231 boys and 210 girls) was drawn consisting the variables of sex, area (rural or urban) and age. The main findings were: (i) the differences between the mean scores of boys and girls on Numerical Ability, Problem solving and Critical Thinking Appraisal Tests were significant at 0.01 level, boys being superior; (ii) there was however, no significant difference between the mean performance of rural and urban students on the six experimental and the criterion variables; (iii) the correlation coefficient between the scores on critical thinking criterion, in case of boys, was significant at a.05 level; (iv) there were

significant differences at .05 level between boys and girls in their correlations in VR and CI, girls being superior in both the cases; (v) the multiple correlation coefficients were: NA and VR = .6005, NA, VR and CI = .6383 and NA, VR, CI and FB = .6525; (vi) the variances of the four tests for school science were 15.6 percent (NA), 13.6 percent (VA), 9.5 percent (CI) and 5.6 percent (FB); (vii) these four tests had highest validity of any combination of tests chosen from the six test used; (viii) three common factors were revealed in this study, which have been named as General factor 'g', Conceptual Facility and Numerical Facility; and (ix) the study revealed agreement, to a great extent, between the findings obtained through multiple correlation and through factor analysis.

**Pathak (1972)** investigated factors which would differentiate high achievers from low achievers in science. To fulfil the objectives in view it was sought to develop a tool to assess the study habits as well as skills of science students. The sample consisted of 105 high and 100 low achievers in science, selected from 1,910 science students of class X of eleven higher secondary schools in Rajasthan. In order to have a representative sample, the schools were selected on the basis of two criteria, viz., (i) the school examination marks and (ii) the scores obtained by students on the achievement test constructed by the investigator. The top ten percent who scored high in the achievement test and whose school marks were also high, were considered as high achievers. The the low achievers were those ten percent who scored less in both. Intelligence, personality traits, interest patterns, socio-economic status and the study habits of high and low achievers were surveyed and compared. The differentiating factors were thus located. Five tools were used: (i) the Jalota's Test of General Mental Ability, (ii) the Mehta's Vocational Interest Checklist, (iii) the Roter's Incomplete Sentence Blank, (iv) an achievement test in science developed by the investigator, (v) the socio-economic Blank and (vi) the study Habits and Skills Inventory. The important findings were: (i) the high achievers had a significantly higher mean IQ (131.2) than the low achievers (93.7); (ii) eighty four percent of the low achievers frequently expressed fear of failure in examination and lack of interest in studies, whereas the high achievers were more optimistic about academic future and they aspired to achieve high standards; (iii) even less confident high achievers did not worry about failure, but they were worried about retaining their division; (iv) the overall socio-economic status of high achievers was significantly higher, (v) the high achievers were mostly from the top three occupational categories, i.e. professionals, semi-professionals, clerical; (vi) the overall adjustment of high achievers was significantly higher than

low achievers; (vii) both had favourable attitudes towards their mother, but were non-committal about their attitudes towards their father; both had hostile attitude towards the older generation; both high and low achievers showed difference in their attitude towards their peers as well; more high achievers had a favourable attitude towards their peer group than the low achievers; (viii) occupation like farming, business, electrical jobs were preferred by equal percentage of high and low achievers; (ix) the educational background as well as the financial condition of parents was better in the case of high achievers; (x) study habits and skills of high achievers were better than those of low achievers; and (xi) the two groups did not differ significantly with regard to their interest patterns.

**Agarwal's (1973)** study was concerned with the preparation of a battery of psychological tests which could predict success in science subjects and the scientific group of the students of high schools. It also aimed at finding out the factors which contributed to the success in science and at helping the teachers to make proper selection for science course. A sample of 300 students of Allahabad city high school studying in class X was selected for tryout of the tests. For the first draft of the tests a sample of 1400 students was selected. Following tests were administered: (i) the Verbal Group Test of Intelligence of Manovignan Shala; (ii) the Minnesota Paper Form Board Test; (iii) the Reasoning Test; (iv) the Numerical Ability Test; (v) the Science Information Test; and (vi) the Science Vocabulary Test. Out of these, the last four tests were constructed and standardized by the investigator. Validity of the tests was computed against three criteria: (i) marks obtained in science; (ii) marks obtained in mathematics; and (iii) total marks obtained in all the subjects at the high school examination. Validity of the battery of tests was found by calculating the multiple correlations of criteria. For this purpose Wherry-Doolittle selection method was used. The tests were selected in the order of their statistical usefulness. The values of multiple correlations were checked with the help of regression equations. Significance of 'R' was also calculated. Success ratios were found out for different selection ratios. Factor analysis was used for analyzing the data obtained from the battery of tests. Thompson's method was used in explaining criteria. Findings revealed that : (i) the first factor had positive loadings on all the tests; it was called a General Factor; (ii) the second factor had high loadings on the criterion (marks obtained in science); it was named as the Interest Factor; (iii) the third factor had loadings on the test of reasoning and the Minnesota Paper Form Board Test; it was named as Reasoning Factor;

and (v) the two sexes differed significantly on all the tests except the Verbal Group Test of Intelligence.

**Chatterjee et al. (1978)** aimed at finding out the effects of scientific interest at different levels of potential ability with respect to science and to study the predictive values of interest in science and scientific aptitude in predicting success in higher secondary science. The sample consisted of 115 students studying in class IX in three different schools in Calcutta, selected at random from Bengali- medium higher secondary boys' school and with ages ranging from 15 to 17 years. The tools used were Scientific Knowledge and Aptitude Test (SKA) and Chatterjee Non-Language Preference Record (CNPR). Product moment coefficient of correlation and multiple regression analysis were the statistical techniques used for analyzing the data. The students were classified into three groups on the basis of their scores on SKA. They were further classified into groups according to three levels of scores on CNPR. The major findings were: (i) there was systemic positive relationship between science interest and probabilities of success in science at different aptitude levels except in the highest aptitude level. (ii) the relationship between aptitude in science and achievement in science was positive. (iii) at the lower level of aptitude, interest played an important role in enhancing the probability of success in science. (iv) the Product moment coefficient of correlation between the scores on CPNR and SKA was found to be 0.14, that between CNPR and higher secondary examination marks was found to be 0.36 and that between SKA and higher secondary examination marks was 0.51. (v) the multiple correlation with marks in the higher secondary examination as the criterion was 0.59 by adding interest score (with proper weightage) to the aptitude scores. (vi) the prediction of achievement in science was significantly improved by considering the scores in scientific scale in CNPR along with the scientific aptitude score.

**Mishra (1978)** investigated the relationship of creativity, intelligence and general anxiety separately among the high and the low achieving students in science, commerce and arts. The stratified random sampling technique was used to draw a sample of 600 cases (200 from each stream) for comparing the high and low academic achievers of arts, commerce and science on creativity, intelligence and general anxiety and to find out intervariable coordination between creativity, intelligence and general anxiety. In all, 400 students, (200 from each sex) for comparing the high and the low achievers sex-wise and 300 students (100 from each stream) for formulating regression equation for predicting academic achievement were randomly selected from the

secondary schools of Rajasthan. The tools used were Mehdi's Test of Creativity, a Verbal Test of Creativity constructed by the investigator, Raven's Standard Progressive Matrices and Sinha's General Anxiety Scale. Critical ratio was employed to analyse the data. Analysis was also presented through graphs. The findings were: (i) the high achievers in arts were higher on the levels of creativity than the low achievers in arts. (ii) the high achievers in commerce were higher as regards the level of creativity than the low achievers in that stream. (iii) the high achievers in science were higher on the level of creativity than their low achieving counterparts. (iv) the high achieving boys in arts had a higher creativity creativity than their low achieving counterparts. The high achieving girls in arts were significantly higher on the level of creativity than the low achieving girls. (v) the high achieving boys in science were higher on the level of creativity than their low achieving counterparts. The high achieving girls in science were higher on level of creativity than their low achieving counterparts. (vi) the high achievers in arts were higher in their level of intelligence than the low achievers. (vii) the high achievers in commerce were higher in their level of intelligence also. (viii) the high achievers in science were higher in intelligence than the low achievers. (ix) the high achieving boys in arts were definitely higher in the level of intelligence than their low achieving counterparts. (x) the high achieving girls in arts were higher in the level of their intelligence than their low achieving counterparts. (xi) intelligence and creativity were statistically correlated among the high achievers in science and commerce and the low achievers in arts. (xii) intelligence and general anxiety exhibited no relationship in any of the streams or levels of achievement except the low achievers in science. (xiii) creativity and general anxiety were related in the case of the low achievers in commerce and science only. (xiv) the science students were more creative, intelligent and low in general anxiety than their counterparts in other streams. The arts students were low in creativity and intelligence but high in general anxiety. The science students exhibited more creative talent and low general anxiety.

**Senapati (1980**) studied interest and ability of the secondary school students in science. The objectives of the study were: (i) to determine the exact relationship between interest and ability, and (ii) to suggest some dependable criteria for guiding students in the science stream of the present school education. The sample consisted of 207 students of age group 17+ chosen at random from among students of Class XI (Science stream) of twelve randomly selected higher secondary schools in West Bengal. Data were collected with the help of Intelligence Test by Pal and Bose, the Bengali adaptation of Strong Vocational Interest Blank by Deb, Scientific Aptitude Test by

Ghosh and Achievement Test in physical science designed on the basis of questions used in Higher Secondary Examination, 1975, of West Bengal Board of Secondary Education. The scored obtained by the subjects in physical science in the school annual examination as well as in the higher secondary final examination were also collected. Correlational methods were used in the analysis of the data. The findings that emerged from the study was that intelligence and interest taken together were a better predictor of achievement in science than interest or intelligence alone.

**Srivastava (1980)** examined intelligence, interest, adjustment and family status as predictors of educational attainment of high school students. The objectives of the study were: (i) to determine the extent of relationship between high school achievement and general mental ability, adjustment, interest and family status, (ii) to develop regression equations for the prediction of achievement from each of the above independent variables, (iii) to locate the variables relevant for prediction and to determine the multiple correlation between the selected predictor variables and high school science group achievement, (iv) to derive the multiple regression equation for predicting achievement, and (v) to determine the efficiency of prediction in terms of the extent of positive and negative fluctuation of obtained marks from predicted scores, the trend of failure in examination at different levels of prediction, and the trend of fluctuation of the obtained results from the predicted scores at different levels of prediction. A total number of 500 students (415 boys and 85 girls) were selected from fourteen intermediate colleges of Gorakhpur. Mean, standard deviation, correction, regression equations and multiple correction coefficient were calculated. The results were: (i) there was substantial correlation between intelligence and achievement and moderate correlation between achievement and socio-economic status. (ii) scientific, clerical interest and educational adjustment were substantially correlated with achievement. (iii) mechanical interests and emotional and social adjustment also had significant positive correlation with achievement.

**Vijaylakshmi (1980)** aimed at finding out the extent to which academic achievement and socio-economic status served as predictors of the creative talent. In view of these objectives, the study examined the following hypotheses: (i) high creatives differed significantly from low creatives with regard to academic achievement. (ii) high creatives differed significantly from low creatives with regard to socio-economic status. The sample comprised of 425 pupils attending six selected secondary schools from the urban and rural areas of a district in Kerala. Care was taken to see that almost an equal number of boys and girls was included. The stratified proportional sampling

technique was employed for the selection of the sample. The tools used were Nair's Kerala University Test of Creative Thinking and Nair's Socio-Economic Status Scale Data Sheet. Academic achievement was measured in terms of the average of the marks obtained by the pupils in different school subjects in the first and the second terminal examinations. The t-test was used for data analysis. The major findings of the study were: (i) there was significant difference between the high creatives and the low creatives in academic achievement. (ii) there was significant difference between the high creatives and the low creatives in socio-economic status. (iii) the average academic achievement of the high creatives was more than the average academic achievement of the low creatives. (iv) socio-economic status had a facilitating effect on the creative ability of the pupils.

**Menon (1982)** examined performance of students at Polytechnics in relation to their Academic Achievements, Intelligence, Differential Aptitudes, Adjustment and Aspiration Level. The major objectives of the study were: (i) to find whether general mental ability (intelligence) had any effect on the performance of students in polytechnics, (ii) to find out whether general adjustment was related to the performance of students in polytechnics, (iii) to find out whether the level of aspiration influenced students' performance in polytechnic examination, (iv) to examine the effect of differential attitudes on students' performance in polytechnics, (v) to find out whether students' achievement in qualifying examination (S. S. C.) was helpful in predicting their performance in polytechnic examination, (vi) to find out whether the aspiration level of students had any relationship with their performance in the polytechnic examination, and (vii) to find out the cumulative effect of all the variables on students' performance through the techniques of multiple regression analysis. The sample consisted of 300 students belonging to two government polytechnics in Haryana. The tools used for data collection were the General Mental Ability Test of Tandon and Jalota, the Adjustment Inventory developed by Patel and others, the Occupational Aspiration Scale of Grewal, the Differential Aptitude Test Battery (DAT) and the Test for Level of Aspiration developed by Shah and Bhargava. The aggregate marks obtained by the students in their matriculation examination were taken as the measure of their achievement. The scores obtained by the students in their final examination of the first year were taken as the measure of their performance in the polytechnics. Data was processed using t-test, product moment correlation and multiple regression analysis. The major findings of the study were: (i) eight factors were differentiated between high and low performance. Some of these factors were: general mental

ability, space relations, numerical ability, mechanical reasoning, language usage (spelling), language usage (grammar) and academic achievement. (ii) in the correlational study, only seven variables were significantly related to the students' performance. They were: numerical ability, general mental ability, abstract reasoning, mechanical reasoning, academic achievement, language usage (spelling) and space relations. (iii) the multiple correlation analysis indicated six variables which together accounted for 38.23 percent of the variance in the criterion variables. These six variables were: numerical ability, general mental ability, abstract reasoning, mechanical reasoning, academic achievement and language usage (spelling).

**Pal (1982**) enquired into the factors involved in the learning of science by adolescent pupils. The main aim of the enquiry was to investigate and analyse the different factors or abilities involved in the learning of science subjects with special reference to physics and chemistry by adolescent pupils. In all, eleven schools in Calcutta and its vicinity were selected by incidental sampling. An intelligent test, Guilford's Problem Solving Ability Test in Arithmetic, an aptitude test, Ballard's Three – Minute Arithmetic Test, and a science achievement test were administered to 200 pre-adult age group students for determining the different factors or abilities in learning science by the adolescent pupils. Correlation matrix and centroid factor matrix were prepared. The major findings were: (i) there was a common factor in all the five tests where general intelligence or educability played significant roles. (ii) General ability of g factor, scientific aptitude/ reasoning, speed and precision and problem-solving ability were significantly responsible for the learning of science. (iii) students belonging to the advanced schools had done better in science achievement test than those in less advanced schools having the same or more or less identical general ability. (iv) good schooling, interest and industriousness also played an important role in the learning of science. (v) there was a significantly high positive correlation between the test scores related to the proposed factors and the marks of physics and chemistry in the Higher Secondary Examination conducted by the West Bengal Board of Secondary Education.

**Chhikara (1985**) investigated into relationship of reasoning abilities with achievement of concepts in life sciences. The hypotheses formulated for the study were: (1) it is feasible to identify the hierarchy of concepts in life sciences into seven levels of organization of biological phenomena and to measure achievement of these concepts through objective tests. (2) it is feasible to identify reasoning abilities that secondary school students (15+) possess with the help of cognition and convergent production of semantic classes, relations and implications tests. (3) there exists a

definite positive relationship between conceptual achievement in life sciences and reasoning abilities. (4) it is possible to predict conceptual achievement in life sciences on the basis of reasoning ability tests. The tools used in the study were battery of Concept Achievement Tests and a battery of Reasoning Ability Tests developed by Girish Bala. The subject content of classes VI to X was analysed and 274 concepts were found out. These concepts were divided under seven levels of organization of biological phenomena. The content was further categorized under the seven themes identified by the BSCS for its curriculum model. Five alternative multiple choice items to measure knowledge, comprehension or application were constructed. For pretry-out it was given to ten students of class X and three teachers for criticism. On the basis of their responses the language and instructions were further modified. All the 280 items were divided into seven parts (tests). This battery of seven tests was administered to 370 students for try-out. The discrimination and difficulty values of each item were calculated and 175 items were selected for the final form of the battery. The KR – 2- reliability coefficient for the Concepts Achievement Tests of life sciences was found to be 0.848 while split-half reliability was 0.886. Nearly 200 students selected from four government boys' senior secondary schools of South Delhi constituted the sample. The findings of the study were: 1. A slight modification was made in the hierarchy levels of organization of biological phenomena when concepts in secondary school life sciences were identified and the concept achievement test was found reliable and valid. All these supported the first hypothesis, i.e. it was feasible to identify the hierarchy of concepts into seven levels of organization of biological phenomena and to measure achievement of these concepts through objective tests. 2. The results of factor analysis of reasoning ability supported that it was possible to identify reasoning abilities that the secondary school students possessed, with the help of cognition and convergent production of semantic classes, relations and implications tests. 3. Indian children did not differentiate as clearly as inferred according to the structure-of-intellect theory. 4. A definite positive relationship between conceptual achievement in life sciences and reasoning ability was found. 5. The fourth hypothesis, i.e. the possibility to predict conceptual achievement in life sciences on the basis of the reasoning ability test, was supported to a large extent by the results of regression analysis.

**Mehna (1986**) investigated into Some factors affecting academic achievement in science of standard IX students of Greater Bombay. The major objectives of the study were (i) to find out the predictors of achievement in science as whole, and (ii) to study sex differences in case of predictors

of achievement in science as a whole. The independent variables selected for the study were nonverbal intelligence, verbal intelligence, abstract reasoning, mechanical comprehension, numerical ability, scientific aptitude, interest in medicine, engineering, commerce, arts, fine arts, motivation for learning science, physics, chemistry, biology and students' liking for teachers of science, physics, chemistry and biology. The criterion variables were achievement in science. The various tools used were Nafda's Non-Verbal Test of Intelligence, OTIS Self-Administering Test of Mental Ability, Bennett's Mechanical Comprehension Test- Form A A, Abstract Reasoning Test- Form A of the D.A.T., Numerical ability Test of D.A.T., Mascarenhas Interest Inventory, Chatterjee and Mukherjee Test of Scientific Knowledge and Aptitude Form 1064, Students Liking Scale by S. P. Malhotra and B. K. Passi, Rating Scale on Motivation for learning science and achievement tests in physics, chemistry and biology constructed by the researcher. The major findings were: Six variables viz., verbal intelligence, motivation for learning general science, scientific knowledge and aptitude, numerical ability, liking for teachers of science and interest in medicine were significant predictors of achievement of class IX students in general science (R= 0.5773). the significant predictor variables for boys were scientific knowledge and aptitude, motivation for general science, verbal intelligence, interest in commerce, numerical ability and liking for science teachers (R = 0.5463). The significant predictors of achievement in general science for girls were verbal intelligence, motivation for general science, scientific knowledge and aptitude, liking for teachers of general science and numerical ability (R= 0.6500)

**Sharma (2000)** studied interrelationship between quantitative achievement and conceptual understanding of the students learning science. The methodology adopted was descriptive method of comparative quantitative correlation type. The sample containing 1967 pupils from IX standard were selected using stratified random sampling technique. A significant relationship was found between the quantitative achievement and conceptual understanding of secondary school subjects.

**Paltasingh (2008)** studied the relationship among creativity, intelligence and achievement scores of secondary school students with the following objectives: to study the correlation between creativity and intelligence, to study the correlation between creativity and science achievement, to study the correlation between creativity and scholastic achievement, to study the correlation between intelligence and science achievement, and to study the correlation between intelligence and scholastic achievement. The study was correlational in nature. A total of 180 students of class IX of two Oriya medium secondary schools constituted the sample of the study. Three tools were

used to collect the data: Jalota's Group Test of General Mental Ability, Baquer Mehdi's Test of Creative Thinking, and finally the Science Achievement test prepared by the investigator himself. After the collection of data, a quantitative analysis was done. The researcher concluded that there was significant and positive correlation between s and intelligence, there was significant and positive correlation between creativity and science achievement, there was significant and positive correlation between creativity and scholastic achievement scores, there was significant positive correlation between intelligence and science achievement, there was significant and positive correlation between total intelligence and scholastic achievement scores.

**Devi Uma (2009)** studied the relationship between problem solving ability and academic achievement of secondary school students with the following objectives: to investigate the problem solving ability of IX standard students based on sex and type of school, to investigate the mean differences, if any, between the level of problem solving ability of IX standard students with their academic achievement, to investigate the relationship between problem solving ability and academic achievement of IX standard students. This investigation study was a correlation type. The sample comprises of 200 IX standard students of which 100 boys and 100 girls were selected randomly from both private and government secondary schools of Davangere city, Karnataka. The researcher concluded that there was no significant difference in problem solving ability of boys and girls, there was a significant difference in problem solving ability of students studying in government and private schools, there was significant difference in academic achievement of students with high, moderate and low problem solving ability, there was a positive relationship between problem solving and academic achievement of IX standard students.

## 2.2. EXPERIMENTAL STUDIES CONDUCTED IN SCIENCE EDUCATION

**Nair (1978)** studied impact of creative methods of teaching on the attainment of higher objectives in science. The major objective of the study was to find out whether creative methods of teaching physics and were superior to the traditional methods in attaining higher objectives. The parallel group experimental design was used. The study was carried out in sic secondary schools selected in the basis of stratified random sampling sampling from North Parur and Kodungallur educational sub-districts of Kerala. The experimental and the control groups were equated on the basis of age, sex, socio-economic status, intelligence and school achievement. The experimental group was

taught through creative methods and the control group through traditional methods. The topics taught were 'solution' from the chemistry syllabus and 'motion of bodies' from the physics syllabus of Standard VII. Standard Progressive Matrices, Socio-Economic Status Scale of Kuppuswamy, opinionnaire and achievement tests were the major tools used for collecting data. The major findings of the study were: (i) the creative methods were superior to the traditional methods like verbal illustration and demonstration in attaining higher objectives in science. (ii) the creative methods were superior to the traditional methods for the sub-samples (sex, management of schools and locality of schools). (iii) the creative methods were superior to the traditional methods in attainment of higher objectives in the case of pupils having different levels of intelligence and socio-economic status.

**Anjaria (1984)** explored systems approach in the teaching of science. The major objectives of the study were (i) to prepare an instructional model with the help of resources for the unit on 'Light' in Std. X, on the basis of the systems approach, (ii) to measure the effectiveness of the systems approach in the teaching-learning process, and (iii) to evaluate the effectiveness of the systems approach in planning the design of the experiment. Students of class X of three different schools of Surat formed the sample of the experiment. In all, there were 248 students selected for the conduct of the experiment. The students in each school were divided into two groups in each of the three schools were matched, with respect to their mean age, previous achievement, and sex. The investigator prepared programmed learning materials, a tape slide visuals programme on the unit of 'light', and a criterion test. She also utilized the available resources like charts, models and film-strips. For measuring intelligence, Patel's Non-Verbal Group Intelligence Test was used. Pretest-posttest with control group experimental design was used. Both formative and summative techniques of evaluation were employed. In group matching, intelligence was controlled statistically by using analysis of covariance. The major findings of the study were as follows: 1. The experimental group scored higher than the control group and the t-test was found to be significant. It could thus be claimed that the systems approach to instruction was more effective than the traditional approach to instruction. 2. With reference to retention of the subject matter, it could be claimed that the systems approach to instruction was more effective than the traditional approach to instruction. 3. Replication of this could raise the level of generalizability. 4. The systems approach was found effective in planning the design of the experiment. It was found effective in maximum utilization of available resources. In the school situation, the systems

approach should be used for designing and managing classroom instruction for planning the curriculum, for scheduling classroom activities, and for evaluation procedures.

**Adinarayan (1984)** conducted a training programme for science teaching in primary schools. The major objectives of the study were (i) to identify areas of competence in the teaching of elementary science, (ii) to evaluate the course in elementary science based on competency required in the teacher, (iii) to develop competence criteria for observational, investigatory and inquiry skills in pupils, (iv) to develop packages of instructional aids for teachers, and (v) to determine the advantages and effectiveness of packages in terms of development of skills in pupils. Two units of the science syllabus of class IV and V, prescribed by the Tamil Nadu Government, were selected for teaching. Instructional packages were prepared for teaching through the experimental method as well as the customary method. A comparison of the effectiveness of the methods was made on the basis of criterion tests for knowledge, comprehension and observation, inquiry and investigatory skills. Some semi-urban and rural schools were selected from Altoor Panchayat Union of Madurai district using stratified random sampling. Forty-eight teachers were selected of whom 24 comprised of the experimental group and were oriented to the objectives of the programme, analysis of the content, methods, and evaluation techniques, organization of classes, administration of tests, and the role of teachers during teaching, discussion, group work and demonstrations. The sample of 760 pupils was divided into equated groups in each school on the basis of age, mental ability and science background test. A criterion test was developed for assessing knowledge and comprehension, observation, inquiry and investigatory skills. Reaction towards science activities was measured through a reaction scale prepared by the investigator. The major findings were as follows: 1. There was a significant difference in the development of skills among students in the experimental group. 2. Class IV students in nine schools and class V students in seven schools of the experimental group indicated an increase in knowledge and comprehension in comparison to the control group of students. 3. As regards to observational skills, class IV students in nine schools and class V students in 11 schools of the experimental group showed significant improvement. 4. Investigatory skills developed significantly in 11 schools in each of classes of the experimental group. 5. Performance of the experimental group in inquiry skills of ten schools in class IV and seven schools in class V increased significantly. 6. The experimental group greatly favoured science activities.

**Deopuria (1984)** compared teaching science through environmental and traditional approach in schools of Madhya Pradesh. The objectives of the study were: (i) to compare the cognitive achievement of students of classes V, VIII, IX and X towards science taught through the environmental versus the traditional approach, (ii) to compare the environmental awareness and attitude of students when taught by the above two methods, and (iii) to compare the attitudes of the teachers towards the environmental approach of teaching. The investigator formulated 15 null hypotheses around the dependent variables related to knowledge, understanding, and application scores, environmental awareness scores, attitude towards environmental problems, and environmental approach. The study employed a two-group design having the environmental approach in the experimental group and the traditional approach in the control group. The study was conducted at three levels: primary school, middle school and higher secondary school. At the primary level, 50 schools having 500 students and 100 teachers in the experimental group and another set of 50 schools, 500 students and 100 teachers in the control group were included. At middle level, the experimental group consisted of ten schools, 250 students and 40 teachers and the control group also included another ten schools, 250 students and 40 teachers. At the higher secondary level, the experimental group included one school, 125 students and ten teachers and the control group at this level also had one school, 125 students and ten teachers. The experimental group represented project schools assisted by UNICEF and NCERT. The non-project schools formed the control group. The control group schools were within the vicinity of 10 km of the project schools. The curriculum was chosen from the Hoshangabad Science Teaching Programme (Kishore Bharti). Some of the sample topics were root, stem, leaf, crops, earth, soil, animals, personal hygiene, health and disease. Three types of tools were standardized. These were achievement tests for classes V, VIII, IX and X; attitude scale for class X; and attitude scale for teachers towards the environmental approach. Statistical techniques such as mean, standard deviation and t-test were worked out for testing the hypotheses. Some of the major findings were: 1. The students of the experimental group of classes V, VIII, IX and X obtained higher achievement scores due to teaching of science through the environmental approach. 2. The environmental approach showed greater cognitive gain in knowledge, understanding and application of science concepts related to environmental education at primary, middle and secondary school levels. But it was not effective in the teaching of factual recall type concepts at middle and secondary school levels. 3. The students of primary schools of the experimental group

showed considerable improvement towards environmental awareness. 4. The environmental attitude inventory showed significant positive gains in attitudes towards the environment for the entire experimental group of students. 5. The obtained value of 't' showed that teachers of the experimental group of schools had a very high positive attitude towards the environmental approach for teaching science. 6. No significant difference between male and female teachers' attitudes towards the environmental approach revealed that sex had no effect on the attitude towards the environmental approach. 7. There was no significant difference between the attitudes of teachers towards the environmental approach followed at different grade levels.

**Barve (1986)** did a study on Preparation Field and Testing of Filmstrips for the Teaching of Science- a Course in Standard IX and Their Comparative Effectiveness in the Teaching-Learning Process as Compared to the Traditional Practice. The objectives of the study were (i) to prepare filmstrips on selected topics from the science course of standard IX, (ii) to teach the selected units of the science course of standard IX by using these filmstrips, (iii) to compare the effectiveness of teaching with the help of filmstrips and the traditional practice of teaching science in terms of the achievement of the learner, (iv) to compare the effectiveness of teaching with the help of filmstrips and the traditional practice of teaching science in terms of achievement of the learner, considering sex and level of achievement as parameters, and (v) to compare the effectiveness of teaching with the help of filmstrips in terms of achievement of the learner considering age, liking and availability of gadgets at home as parameters. The researcher developed ten filmstrips based on units of science from the syllabus. In order to study the effectiveness of the filmstrips, the researcher used untreated control group design with pretest-posttest. The students for the experiment were chosen by the incidental sampling method. Pre-achievement and post-tests were administered to both the groups. The test scores were analysed by using analysis of variance. The major findings of the study were: 1. Filmstrip was more effective than the traditional method for teaching the facts, principles and concepts in science. 2. Filmstrip and the traditional methods were equally effective for teaching abstract concepts in science. 3. Filmstrip was an effective teaching aid for all levels of learners, i.e. low, medium and high achievers. 4. Filmstrip was more effective for the learners between 13 and 16 years of age than for learners between 17 and 21 years of age. 5. Filmstrip was a more effective method of teaching science for both sexes, i.e. males and females.

**Joshi (1987**) investigated Evolvement of an Instructional Strategy for Teaching Elements of Science to Class IX Students of M. P. State. The objectives of the study were (i) to develop an

instructional strategy and study its effectiveness in terms of students' performance on criterion tests and students' reactions towards various components of the instructional strategy as a whole, (ii) to compare the mean achievement scores of students taught through the developed instructional strategy with those taught through the traditional method by taking intelligence as a covariate, (iii) to compare the mean scores of higher mental ability in science of students taught through the developed instructional strategy with those taught through the traditional method by taking intelligence as a covariate. The hypotheses were: (1) the adjusted mean achievement scores of students taught through the developed instructional strategy will not differ significantly from those taught through the traditional method when intelligence is taken as a covariate, (2) the adjusted mean higher mental ability scores of the students taught through the developed instructional strategy will not differ significantly from those taught through the traditional method when intelligence is taken as a covariate. The study was experimental in nature and was conducted in two stages – try out and field study stage. The sample at the try-out stage comprised 30 students of class IX studying Kamala Nehru Higher Secondary School, Indore. All students were females. The sample for the field study comprised 109 students studying in class IX. The design of the study was post-test only control group design. The findings of the study were: 1. The developed instructional strategy (IS) was found to be effective in terms of achievement of students on criterion tests and reactions of students towards different components of the IS and IS as a whole. 2. The developed IS was found to be significantly superior to the traditional method when the students' mean achievement scores were not adjusted with respect to intelligence. 3. The developed IS found significantly superior to the traditional method in terms of the development of higher mental ability in science when their mean scores on the test of higher mental ability in science were adjusted with respect to intelligence.

**Agnihotri (1987)** studied influence of some of the methods of teaching Physics on the achievement in Physics of class X students in Delhi. The objective of the study was to test the following hypotheses: (i) There is no significant difference between the mean achievement in physics of different groups of students taught by different methods, viz., lecture-cum-demonstration method, laboratory method, programmed instruction and assignment-cum-discussion method. (2) the interaction between teaching methods and different schools in not significant. (3) the interaction between teaching methods and different levels of students is not significant. The investigation followed the pretest post-test experimental method of research where

two units of physics were taught according to the design by different methods viz., the method devised by the investigator, the traditional method or the lecture-demonstration method, programmed instruction and assignment-cum-discussion method. For the experiment ten schools were selected from Delhi in which physics was taught. A sample of 520 grade X students was selected. They were divided into four groups of 130 each. The achievement of students in physics in each of the four groups in each of the schools was similar prior to the experimental teaching. The tools used were: (i) An achievement test, (ii) the programmed learning material and, (iii) instructional material for different teaching methods. The findings of the study were: 1. The traditional method or the lecture-cum-demonstration method followed by the verification type of laboratory work was more effective than the assignment-cum-discussion method but this method was less effective than the programmed instruction method for the teaching of physics. 2. With respect to achievement in physics, programmed instruction for the teaching of physics was less effective than the method of teaching physics systematically designed by the investigator, but this method was found to be more effective than the assignment-cum-discussion method and the traditional method or the lecture-demonstration method followed by the verification type of laboratory work. 3. Out of all four methods, the method of teaching physics systematically designed by the investigator was found to be most effective with respect to achievement in physics and the assignment-cum-discussion method was found to be the least effective with respect to achievement in physics. 5. The relative effectiveness of all the four methods with respect to achievement in physics was the same, not only for all the schools but also for all the levels of students. 6. If all the four methods selected for this investigation were ranked with respect to achievement in physics, it was found that the method of teaching physics systematically designed by the investigator was the first, the programmed instruction modified by the investigator for the teaching of physics was the second, the traditional method or the lecture-demonstration method followed by the verification type of laboratory work was the third and the assignment-cum-discussion method was the fourth.

**Pillai (1987)** carried an experimental study of Gagne's conditions of learning for instruction in Physics at secondary level. The objectives of the study were: (i) to design an instructional strategy based on Gagne's conditions of learning, (ii) to experimentally validate the instructional strategy developed, (iii) to examine whether the acquisition of higher order capabilities necessarily included lower order capabilities also, and (iv) to determine whether the instructional strategy

adopted brought about any changes in cognitive preference of the learner. Two divisions of the standard IX with the 38 and 37 students in them, of a higher secondary school of Baroda affiliated to the CBSE were randomly chosen as the experimental and control groups for the study. The experimental group was provided with instructional events in physics developed in accordance with the conditions of learning as enunciated by Gagne. The instructional events consisted of (1) informing the learner of the objectives, (2) stimulating the recall of pre-requisite learning, (3) presenting the stimulus material by way of instruction, (4) providing learning guidance by way of hints, (5) eliciting performance through individual practice, (6) providing feedback about the performance correctness, (7) enhancing retention through self-learning, (8) providing feedback about individualized self-learning material, (9) assessing performance, and (10) providing feedback based on the assessment. Instruction in the control group was through traditional lectures based on the textual material. The teachers teaching the two groups were interchanged after half the programme was over. The instructional materials developed by the investigator were (1) classroom learning material, (2) home assignment material consisting of self-learning material and self-evaluation material, and (3) assessment material. For studying the cognitive preferences, 20 suitable items were selected from the Science Cognitive Preference Inventory developed at the Science Education Center, University of Iowa. The experimental strategy was validated through criterion tests for each unit and a comprehensive test and also the annual examination. The data were analysed using percentiles, mean, standard deviation, analysis of covariance, chi-square test and t-test. The study generated the following major findings: 1. The instructional strategy developed based on Gagne's conditions of learning was found feasible for normal classroom teaching. It was found more effective than the traditional method of instruction in terms of student performance. 2. Successful problem solvers were those who had shown better performance at the concept and the rule levels. Hierarchical relationship was found in the learning of intellectual skills with problem solving at the apex followed by rules and concepts. 3. The hierarchy in learning di not depend on the types of instructional input and their sequencing. 4. The instructional strategy based on Gagne's conditions of learning was found to change the cognitive preference from facts and applications to principles and problem solving.

**Vaidya (1991)** conducted a study on Developing teaching learning strategies for enhancing students' achievement in science. Random sampling method was adopted to draw thirty three students who were studying in grade VI of the Mother school and the Mirambica School. Relevant

data were collected using a questionnaire and the Modules. Study reveals that, it was possible to accelerate thought provoking problems in their hierarchical order but abstract piagetian schemes of thought were difficult to crack.

**Upadhyaya (2001)** carried out a study on Inquiry Training Model (ITM): An investigation into the Effectiveness of ITM in teaching of science in secondary schools of Gujarat. The main objectives of the study were to study the effectiveness of ITM in terms of students higher mental ability in science, general creativity, scientific creativity, inductive reasoning ability, theory building capacity, achievement in science and reaction towards (ITM), to compare ITM with Traditional Method (TM), to study the influence of Treatment, Sex and their various interactions on students. The sample comprised of 226 students (132 boys and ninety four girls) of class IX of different schools. The study was an Experimental in nature and it employed Pretest Posttest Non equivalent Control Group Design. The tools used were Intelligence test, SES scale, Higher Mental Ability in Science test (HMA in Science), General Creativity test (GC), Science Creativity test (SC), Inductive Reasoning Ability test (IRA), Theory Building Capacity test (TBC), Achievement in Scientific Aptitude scale (SA), Science Attitude scale and Reaction Towards ITM scale. The major findings of the study were ITM was found to be more effective than TM in terms of GC, SC, IRA, TBC, achievement in Science and reaction towards ITM, but in case of HMA in Science ITM and TM were found to be equally effective ITM was found to be significantly superior to TM in terms of GC, SC, IRA, TBC, Achievement in Science, but ITM was found to be insignificant in terms of HMA in Science when the groups were matched statistically with respect to Intelligence, SES, scientific Aptitude and precious Achievement in Science.

**Padma Priya (2012)** developed a metacognitive skill based package for enhancing metacognitive skills and achievement in biology of secondary students. The purpose of the study was to prepare and standardize a Metacognitive Skill Assessment Scale (MAS) and determine its effectiveness on achievement of secondary school students in biology. The sample consisted of 190 class IX students, 95 each from experimental and control group. Pretest posttest non-equivalent group design was used by the researcher for the study. Bloom's taxonomy was followed by the researcher for measuring the achievement of the students. The study was experimental in nature. The researcher found a significant difference in the achievement of experimental group students and control group students after the experiment.

**Shelat (2012)** developed and implemented an instructional strategy to enhance science comprehension among class VII students. The objectives of the study were: to study the teaching procedure followed by teachers in science teaching, to determine the science comprehension among class VII students, to development and implement an instructional strategy for enhancement of science comprehension of students and to study its effectiveness. The sample consisted of fifteen science teachers and one experimental group of 52 class VII students and one control group of 42 students of the same class. The pretest posttest non-equivalent group design was employed for the study. The researcher concluded that traditional method was used by most of the science teachers while teaching science and there was a significant difference in the comprehension of experimental group students as compared to control group students.

**Tandel (2012)** conducted a study for development of metacognitive skills in science student teachers through constructivist approach. The objective of the study was the development of metacognitive knowledge and metacognitive regulation in science student-teachers while learning science through constructivist (5E model) approach. Mixed method approach was used to conduct the study. The sample consisted of ten science student teachers having good academic records. Observation, interview, reflection essays and metacognition inventory were the tools used for the study. The researcher concluded that constructivist approach definitely provided greater opportunities for development of metacognitive skills and their different characteristics found expression during each stage of 5E model.

**Pillai (2013)** developed and implemented an intervention programme for class IX students for teaching physics. The objectives of the study were: to identify the topics of physics from standard IX Science and Technology for Intervention; to develop and implement an Intervention programme in the physics content of standard IX Science and Technology; to study the effectiveness of the developed Intervention Programme in terms of achievement of students on the conceptual understanding of physics concepts, interpretation of Physics concept from the stories, identification of Physics concepts from the images of events projected, logical sequencing of Physics concepts from the images of events projected; to study the reactions of the students towards the developed Intervention Programme. The study was conducted in three phases and it was experimental in nature. Sample of the study consisted of 38 class IX students. The researcher concluded with findings that the intervention programme was effectively helpful to the students to

improve their achievement as well as conceptual understanding in physics. Also the students had a positive and favourable reaction towards the intervention programme.

**Masalegoo (2013)** conducted a study on project based learning in relation to higher order thinking abilities and creativity among under graduate students. Researcher framed 12 null hypotheses to study the significant difference between experimental and control groups. Experimental design was employed to conduct the study. In this research PBL means style of teaching and learning that the researcher used in order to measure the influence of four variables (thinking skills, creativity, problem solving and team-collaboration) in the development of higher order thinking. The researcher framed four tools for each variable. The sample size of the study was 84 students each in both the groups. The data was analysed using t-test and Mann-Whitney U test. The major findings of the study were: thinking skills, creativity, problem solving and team-collaboration as parameters of PBL method, are considered determinant factor in higher order thinking, significant differences were found between the experimental and control groups in terms of creativity, thinking skill, problem solving and team – collaboration. Significant difference was found between girls and boys of the experimental group in terms of thinking skill, problem solving, creativity and team – collaboration. However, no significant difference was found between the girls and boys of the control group with reference to the above mentioned variables.

**Mishra (2016)** explored the impact of Science-Technology-Environment-Society (STES) approach on the development of higher order cognitive skills (HOCS) of the students. Some of the major objectives of the study were: (1) to study the view of teachers on incorporation of STES approach and fostering of Higher Order Cognitive Skills (HOCS) in science, (i) explore the perception of teachers on the STES approach in science education, (ii) to identify the strategies undertaken by the science teachers in order to foster the higher order cognitive skills in science teaching learning process. (2) to study the perception of the students on Science-Technology - Environment- Society (STES) issues. (3) to assess the higher order cognitive skills of the secondary students that results due to application of STES- based issues (i) to assess the problem solving-decision making abilities of secondary students on STES-based issues, (ii) to assess the question posing abilities of secondary students on STES- based issues. Descriptive qualitative method was employed for the study. Sample of the study were 120 class IX students selected randomly and 12 secondary level science teachers. The tools employed were checklists, problem solving-decision making questionnaire, likert type perception scale, semi structured interview

schedule for science teachers and field notes for classroom observation. The overall findings suggested that the students had attempted to make effective usage of their higher order cognitive skills while dealing with the STES issues. The study revealed that students had effectively identified the problem but were unable to explain valid reason of the problems. Very limited number of the students could suggest more than one solutions of the problem. When asked to make decisions, the response of the students was not very encouraging. The decision making ability and question posing skills of majority of the students were not encouraging and needed efforts from various corners. Few students had displayed the ability to solve problems, ask meaningful questions, choose among alternatives and make decisions.

## 2.3. STUDIES CONDUCTED ABROAD

**Brownstein (1985)** studied the adaptation and application of Bloom's taxonomy of educational objectives: cognitive domain to science education in the People's Republic of China. The target group of the study was chemistry teachers who were in the preparation phase in the city of Tinajin. The researcher established three criteria to judge the transferability of Bloom's taxonomy rom the educational culture of United Stated to that of People's Republic of China. However, no attempt was made to compare the cultures of both the countries. The study was designed to be formulative or exploratoty one. The study consisted of three tests: 1. A test for philosophical compatibility – the questionnaire was administered on the educational leaders in Tinajin and college teachers at the Tinajin Normal University. An attempt was made to conduct personal interviews also. 2. A test for language compatibility in translation – the translated work done by Chinese scholars and colleagues was supervised by the researcher. Validity and reliability were established for the test. The Chinese documents were again translated to English by the third translator who had not seen the original document previously. The translation of the Taxonomy was tested for reliability in the following way: The taxonomy would be taught to a Chinese chemistry teacher with the use of the validated translation. The researcher and the Chinese chemistry teacher would each analyze a set of chemistry questions with the use of Bloom's Taxonomy. If they would both concur in their assignment of questions to specific categories of the taxonomy, then the translation of the Taxonomy would be considered to be reliable. 3. A test for cultural compatibility - The translated taxonomy was to be used with two practice groups: a group of experienced teachers of Middle School chemistry and a group of senior college students who would soon become chemistry

teachers. They would be tested to determine a base level for their questioning techniques. They would be taught Bloom's Taxonomy, then they would be retested to determine whether there had been a change in their questioning techniques after they had knowledge of Bloom's Taxonomy and its application. It was hoped that the inclusion of these two different groups might cast light on the influence of experience and position among Chinese educators on the acceptance of this new idea. In summary, it was determined through this study that Bloom's Taxonomy is compatible with Chinese educational philosophy as it was viewed by the Chinese who were involved in this project. The actual tests indicated a definite change in the types of questions that were asked by the subjects after they learned Bloom's Taxonomy. All categories beyond knowledge and comprehension were used more frequently by the subjects, except for the last category, evaluation. It was noted that, in China, students are not expected to take part in decision making or values testing in the classroom. To develop questions which would involve students in these activities would demand a drastic cultural shift on the part of the subjects.

**Nicholas et al. (2003)** measured the effect of using Bloom's taxonomy as a feedback mechanism in an effort to build students' critical thinking skills. Two faculty members participated in the study. The taxonomy was explained to the students and the group and individual assignments and class discussion was conducted to check that the students had knowledge of the taxonomy. A rating- scale questionnaire, known as the checklist was developed and included six items corresponding to the six steps of Bloom's hierarchy of cognitive development. The study used a repeated-observations, single phase design with the independent small samples. The observations were qualitative. Students' submitted assignments were content analysed. Thus the content analyses were quantified. The researchers used non-parametric statistics after each assignments' feedback. Specifically, they used Wilcoxon's distribution – free rank test. It was found that in each class the difference between the median score of the students who demonstrated improvements and the median score of the students who demonstrated decline was significant and positive. The researchers concluded that repeated attention given by students to the steps of Bloom's taxonomy might increase their propensity to apply higher levels of conceptual sophistication to their work.

**Starnes' (2005)** action research study analyzed the use and effectiveness of the Revised Bloom's Taxonomy to align objectives, instruction, and assessment specifically for metacognitive thinking skills in an exit-level medical-surgical nursing course. Three students in the pilot study and 18 students in the dissertation study from two clinical sections of the same nursing course comprised

the sample in the investigation. The dual format of the course allowed analysis of both the clinical laboratory and classroom environments. A qualitative, descriptive, practical action study provided the methodological framework for the research. A variety of data collection methods comprised the tools for information gathering viz., reflective journals, diagnostic reasoning worksheets and observations/individual discussions. Reflective journaling, core questioning, and diagnostic reasoning worksheets were used as assessment methods for the course. Two areas were addressed, the instructor's perceptions through reflection on the process of implementing the Taxonomy and student's ability to integrate metacognitive strategies through the use of diagnostic reasoning in both the classroom and clinical setting. Data obtained from both learning environments, as well as from the instructors and students were triangulated. The findings illuminated the processes involved with using the Revised Bloom's Taxonomy to achieve metacognitive thinking outcomes. Students' thinking processes evolved independently allowing interesting case studies to emerge within the research population. The majority of students produced acceptable outcomes, as defined by criteria for demonstrating metacognitive thinking.

**Gilligan (2007)** This study was designed to determine whether teachers perceived traditional or alternative measures as most effective for the assessment of higher-order thinking skills. Surveys, containing both quantitative, close-ended and qualitative, open-ended questions were sent electronically to college-preparatory, high school teachers in St. Louis City and County. An analysis of the data from 67 respondents indicated that the teachers clearly perceived alternative methods of assessment as most effective for evaluating higher-order thinking skills—particularly application and synthesis. Teachers also felt that their administration encouraged both the instruction and assessment of higher-order thinking skills, as was recommended by this study. Despite this, teachers stated that they used traditional methods of assessment more frequently than they did alternative methods. This study further explored the reasons for this discrepancy and offered suggestions to teachers, administrators and researchers for the effective assessment of higher-order thinking skills.

**Betts (2008)** utilized Bloom's Taxonomy of educational objectives to guide course design and assessment considerations. The development of a core MBA level organizational behavior course served as an example. Their approach to course design used a modification of Bloom's Taxonomy. Researchers reduced the taxonomy to three levels Low: knowledge or understanding, Meddle: application or analysis and High: synthesis or evaluation. The basic approach involved three ideas.

First, class time should be used primarily for the middle level. Second, course elements needed to correspond to and address course learning outcomes and the third consideration was that the course elements (and learning outcomes) could be assessed. Many techniques or 'course elements' could be used in designing a course. Some of the course elements used in a graduate level organizational behavior course were online quizzes, supplement lessons, in-class discussions and exercises, discussion board, essay quizzes, individual and group projects and; management portfolio. In conclusion, the researcher proposed a simple approach to designing a graduate course. The approach allowed for various levels of learning and the different knowledge, skills, abilities and experience that students brought to the course. It addressed the coverage and assessment of learning outcomes, which were essential for high quality programs. The key ideas were to use a variety of methods and techniques, use the classroom for analysis and application level learning, have basic knowledge and understanding (low level learning), and synthesis and evaluation (high level learning) covered outside of class, and to develop tables such as those presented to help in the development and assessment processes.

**Crowe (2008)** developed the Blooming Biology Tool (BBT), an assessment tool based on Bloom's Taxonomy, to assist science faculty in better aligning their assessments with their teaching activities and to help students enhance their study skills and metacognition. The work presented here shows how assessment tools, such as the BBT, can be used to guide and enhance teaching and student learning in a discipline-specific manner in postsecondary education. The BBT was first designed and extensively tested for a study in which we ranked almost 600 science questions from college life science exams and standardized tests. The BBT was then implemented in three different collegiate settings. Implementation of the BBT helped us to adjust our teaching to better enhance our students' current mastery of the material, design questions at higher cognitive skills levels, and assist students in studying for college-level exams and in writing study questions at higher levels of Bloom's Taxonomy. From this work we also created a suite of complementary tools that can assist biology faculty in creating classroom materials and exams at the appropriate level of Bloom's Taxonomy and students to successfully develop and answer questions that require higher-order cognitive skills.

**Halawi et al. (2009)** a model of e-learning through WebCT using Bloom's (1956) taxonomy among a sample of management information systems (MIS) students from one university in the south- eastern region of the United States. The theoretical structure of the present research was

based on individual traits and the environmental background of the students The present conceptual framework was based on the theoretical perspectives of Bloom's taxonomy and the revised Bloom's taxonomy. The independent variables were classified as follows: individual factors (i.e., age, gender, educational level, familiarity, time dedicated to study, knowledge of computers, motivation, learning style) and instructional factors (i.e., effectiveness of tools used, interaction with the professor, ease of use of technology In the present research, investigators sought to answer the following question: What relation existed among individual-related factors, instructional factors, and e-learning through WebCT? On the basis of the research question, they tested the following hypothesis: "A positive relation exists among individual-related factors, instructional factors, and e-learning". To test the proposed hypothesis, they developed measurements for each variable. A combination of questionnaires was used for evaluating e-learning through WebCT. There were nine demographic questions and 22 Likert-type items based on the six cognitive factors that Bloom (1956) proposed to measure individual and instructional factors. investigators administered 75 surveys to students and received a total of 51 surveys. A regression analysis was performed to observe the relation among individual factors, instructional factors, and learning through WebCT. The independent variables comprised the following: (a) individual factors such as gender, age, educational level, familiarity, time dedicated to study, and learning style and (b) instructional factors that include effectiveness of tools used, interaction with the professor, and ease of use of technology. The calculated coefficient of determination ($R^2$) came out to be .093. The independent variables accounted for 9.3% of the variation of learning through WebCT. *F* statistic was also calculated, 0.749, which was insignificant at the .01 level. Investigators concluded that Bloom's taxonomy had been used to evaluate the effectiveness of e-learning and was widely known and accepted. The present exploratory study provided a framework to use Bloom's taxonomy to study e-learning effectiveness across curricula and e-learning delivery toolsets. Further, the present study was significant because it provided an empirical measure that had not been applied previously in this setting.

**Love (2009)** examined presence in state standards of the *Taxonomy of Educational Objectives: Cognitive Domain* (referred to Bloom 1 in this study) and *A Taxonomy of Learning, Teaching, and Assessing* (referred to as Bloom 2 in this study) in this qualitative investigation. Standards for the English language arts eighth grade curriculum were chosen for examination in order to maximize the opportunity for all Bloom levels to appear; all states have language arts standards and eighth

grade is the highest grade level at which NCLB testing is mandated. The standards documents of the 36 stated that have language arts standards unique to eighth grade comprised the analyzed data source and were accessed from state education websites. Descriptive narrations of cognitive levels, benchmarks, indicators, strands, sub-strands, writers of the standards, and any and all references to Bloom 1 and Bloom 2 were investigated. Inter-coder reliability was calculated to address the major research question regarding the clarity of reference to cognitive level of the standards. The qualitative content analysis research methodology chosen to answer the study's research questions culminated in the emergence of four major themes. 1) The extent to which the state standards were classifiable according to Bloom 1 or Bloom 2 depended largely upon consonance in assumptions made by the coders regarding a presumed conditions component for the standards; state standards lack condition components specifying what learners are presented with or have access to at the time the competency stated in the standard is demonstrated. 2) Eighth grade English language arts state standards incorporate cognitive learning levels of Bloom 1 and/or Bloom 2 through the range of Bloom levels. The verb "use" was noted as the most frequent taxonomic verb appearing in the standards. 3) Only five states directly referenced Bloom 1 or Bloom 2 in the documents' introduction/overview, table of contents, document guides, acknowledgements, appendices, and/or bibliography. 4) Of the 2,566 standard statements examined, 96 percent appear to be above the lowest Bloom 1 (Knowledge) and Bloom 2 (Remember) level, employing the researcher's assumed condition component. Overall, results showed that while some states incorporate Bloom 1 and/or Bloom 2, a majority of the standards appear to be written in the lower levels of the Bloom taxonomies. The researcher suggested strategies such as collaboration, consulting, training, and surveying students, parents, teachers, administrators, state committees, and agencies on knowledge of and inclusion of the Bloom taxonomic frameworks in order to improve the clarity of the intended cognitive levels set by the state standards.

**Wruck (2010)** With importance placed on upper level cognitive skills in higher education and with an increased use of distance learning, instructional strategies should be used that support the acquisition of skills such as critical thinking by learners. The purpose of this study was to determine, for the purposes of improving instructional design techniques, if a pattern existed between five selected instructional design strategies and the level of cognition, based on Bloom's taxonomy, achieved by learners in an asynchronous learning environment. The computer-mediated communication (CMC) instructional strategies discussed in this study include (a) *read and*

*respond*, (b) *scenario*, (c) *case study*, (d) *controversy/debate*, and (e) *search and critique*. Using a mixed methodology, data were collected and, using interpretational analysis, themes were identified between multiple constructs. The first series of constructs included the five instructional strategies listed above. The second series of constructs included the six levels of cognition based on Bloom's taxonomy, which include (a) knowledge, (b) comprehension, (c) application, (d) analysis, (e) synthesis, and (f) evaluation. Using four online courses in a doctorate business program, 491 learner responses were collected and evaluated to determine the level of cognition achieved. Descriptive statistics was used to numerically assess the relationship between the two constructs. The findings of this study show that the learners achieved the application level of cognition (Bloom's level 3) when responding to four of the five CMC instructional strategies *controversy/debate*, *case study*, *scenario*, and *search and critique*. Learner responses achieved a cognitive level of comprehension (Bloom's level 2) when responding to *read and respond* instructional strategies. The results also showed that only 4% of the learner responses achieved Bloom's higher order cognitive level of synthesis or evaluation, whereas 83% of all learner responses in this study fell between Bloom's comprehension (level 2) and analysis (level 4). Although the research shows that a pattern exists, the results also show that learners did not achieve the desired higher levels of cognition that would involve critical thinking skills.

**Miser (2017)** The study explored the experiences of effective secondary (high school, grades 9-12) teachers in assessing higher order thinking skills. For students to graduate an Ohio public school, they are to have the resources and skills to be college and career ready and according to Ohio's Learning Standards ("Ohio Department...*Ohio's learning*," 2017b) developing higher order thinking is part of this mandate. Because of these demands, increased focus and attention is being directed to the development of knowledge beyond basic recall and rote memorization and towards deeper understanding, critical thinking, and problem solving. The methods used for this study were based on a design that was a qualitative phenomenology that used a social constructivist framework and an ontological philosophical basis. Seven teachers from an Ohio secondary public-school district were the participants. Empirical data were collected through in-depth interviews and analysis of the data was through horizonalizing and finding themes, developing textural descriptions, and deriving meanings and essences. Twelve themes were constructed—internal classroom themes of defining higher order thinking, questioning, collaborative groups, problem/project based learning, demonstration of skills, instilling confidence, time; and external

themes of administrators, professional development, teacher training, Common Core (Ohio Learning Standards), and collaboration with other teachers.

**Saido et al. (2018)** aimed at assessing 7th grade students' higher order thinking skills level. The higher order thinking level test (HOTLT) was developed based on the Bloom's Taxonomy of cognitive domain and consisted of 20 multiple-choice questions. The test was distributed to a randomly chosen sample comprising 418 7th grade students in the Iraqi-Kurdistan region. The overall findings revealed that the majority of the 7th grade students were at lower level of thinking skills (LOTL) n = 278 (79.7%). More male students were at lower level than female students. However, there was no significant difference between students' level of higher order thinking skills and their gender ($p > 0.05$). Based on the results of students' level of higher order thinking skills, the study provided evidence that almost all students need to improve their higher order thinking skills especially the synthesis and evaluation skills required for improving students' creativity in science.

## 2.4. SUMMARY OF REVIEW OF RELATED STUDIES

The summary describes the research trend in since education in brief. The demographic as well methodological information is presented so that implications can be drawn for the present study. In all the studies related to scientific attitude and aptitude tests the sample of the study was class IX students (Venkataraman, 1970; Sharma, 1975; Ghosh, 1986; Patel, 1997) and class X students (Dave, 1964). The studies were conducted in various parts of India – Gujarat (Dave, 1964; Patel, 1997), Andhra Pradesh (Venkataraman, 1970), Delhi (Sharma, 1975) and West Bengal (Ghosh, 1986). Through these studies, the correlates and determinants of scientific attitude were sought. The variables considered in the studies were sex and place of location (Venkataraman, 1970; Ghosh, 1986; and Patel, 1997), SES (Ghosh, 1986 and Patel, 1997) and management (Venkataraman, 1970). It was found out in the above studies that scientific attitude and scientific aptitude had a positive correlation with and could serve as determinants of each other (Venkataraman, 1970 and Ghosh, 1986) whereas achievement in science and general achievement of students were other determinants of scientific attitude (Patel, 1997).

Second section of the review was related to studies focusing on construction and standardization of achievement tests in science (Aram et al., 1957; Buch, 1960; Saxena, 1960; Gupta, 1962; SIE (Kerala), 1965; Sheth, 1967; Dash, 1967; Rup Prakash, 1968; Vanajakshi, 1970; Bhatt, 1971;

SCERT, 1971; Singh, 1973; Islam, 1975; Sharma, 1975; Sharma, 1976; Ansari, 1984) and subjects of science – Ravindranathan (1983), in Physics and Chemistry (Bountra, 1970; Bhola, 1978; ) in Physics (Sali, 1977; Chhaya, 1978; Khandelwale, 1981;) and in Chemistry (Ghosh, 1985). The studies were conducted in various parts of the nation – Gujarat (Buch, 1960; Bhatt, 1971); Uttar Pradesh (Saxena, 1960; Boutra, 1970); Kanpur (Gupta, 1962); Orissa (Dash, 1967); Punjab (Rup Prakash, 1968); Andhra Pradesh (Vanajakshi, 1970; SCERT, 1971); Bombay (Bhatt, 1971; Singh, 1973; Chhaya, 1978; Ansari, 1984); Haryana ( Gupta, 1974; Bhola, 1978); Bihar (Islam, 1975); Rajasthan (Sharma, 1975; Sharma, 1976); West Bengal (Ghosh, 1985) and Delhi, Calcutta and Madras (Chhaya, 1978). The tests were constructed for students of Telugu medium (SCERT, 1971); Sindhi medium (Singh, 1973); English and Malayalam medium (Raveendranathan, 1983) and Hindi medium (Ansari, 1984). The methodology adopted in these studies was in phases – tryout and main administration of the tools. Validity and reliability were ensured for the achievement tests constructed by the researchers. Sex was one variable utilized in the studies by SIE (Kerala) (1965); Vanajakshi (1970); Bhatt (1971); SCERT (1971); Islam (1975); Sharma (1975); Sharma (1976); Ansari (1984); Ghosh (1985). There was significant difference found in the achievement and/or performance of boys and girls. (SIE (Kerala), 1965; Bhatt, 1971; SCERT, 1971; Sharma, 1975; Sharma, 1976; Ansari, 1984).

In the third section of the review of related literature, different predictors of achievement were either tested or found out. Interest in science (Chatterjee et. al., 1978; Srivastava, 1980;), intelligence (Jha, 1970; Mishra, 1978; Srivastava, 1980;), SES (Srivastava, 1980; Vijayalakshmi, 1980), creativity (Mishra, 1978; Vijayalakshmi, 1980), attitude towards science, verbal meaning, inductive reasoning, numerical ability, reasoning ability, conceptual understanding, problem solving ability were the major predictors and/or correlates of achievement in science (Baqer, 1965; Senapati, 1980; Chhikara, 1985; Paltasingh, 2008; and Devi Uma, 2009). In the studies which considered sex-wise difference in the achievement, significant differences were observed (Jha, 1970; Nayar, 1971). However, not each of the reviewed studies found that the above mentioned factors were positively or statistically correlated predictors. There were studies which showed even negative (Jha, 1970) or no correlation (Baqer, 1965; and Jha, 1970) between some of these factors and the achievement in science.

In the light of experimental studies reviewed, it was found that the treatments given in all those studies were effective and superior to traditional ways. The experimental groups were found to be

superior to the control groups. In the reviewed studies the science was taught through creative methods (Nair, 1978), system approach (Anjaria, 1984), environmental approach (Deopuria, 1984), using filmstrips (Barve, 1986), instructional strategy (Joshi, 1987), Gagne's conditions of learning (Pillai, 1987), metacognitive skill based package (Padma Priya, 2012), constructivist approach (Tandel, 2012), Project based learning (Masalegoo, 2013) and Science-Technology-Environment-Society (STES) approach (Mishra, 2016). The various purposes for which the experiments were carried out were enhancement of comprehension/achievement (Adinarayan, 1984; Deopuria, 1984; Joshi, 1987; Vaidya, 1991; and Padma Priya, 2012), higher order abilities ( Upadhyaya, 2001; Masalegoo, 2013 and Mishra, 2016) and metacognitive skills (Padma Priya, 2012 and Tandel, 2012) and achievement in science (Padma Priya, 2001 and Vaidya, 1991).

Under the category of studies conducted abroad, the review included studies conducted utilizing Bloom's taxonomy (original as well as revised) and higher order skills. It was found that Bloom's taxonomy was a well-known tool to direct the teaching-learning and assessment practices not only in school education (Saido et al, 2018) but also in the higher education (Wruck, 2010). It was used and accepted for instructing medical course students (Starnes, 2005) and management course students (Betts, 2008). It was also used as a framework for evaluating e-learning content (Halawi et. al., 2009). With the support of Bloom's taxonomy studies were conducted for development of higher order skills among the students (Nicholas et. al., 2003 and Crowe, 2008).

## 2.5. IMPLICATIONS FOR THE PRESENT STUDY

The reviewed studies reveal a trend of research in science education. The first ever study conducted in science education was construction of achievement test in science. Thereafter, studies conducted in the same line followed a pattern of construction and standardization of achievement tests in science. It is to be noted here that construction and standardization of tests for science dominated the field of science education in India for more than one decade. The other methods of research in science education were introduced later on.

Methodologically, all the studies adopted survey method. Construction and standardization of test require to be tried out on a larger size of the sample. The procedure for executing the research on construction and standardization can be developed in following stages: Objective formation, content analysis, experts' validation, tool construction, try-out of the constructed too, item analysis in terms of validity and reliability, norms establishment, tool finalization, administration of the

finalised tool on a larger sample size, hypothesis testing, arriving at the conclusion. Item analysis was done by calculating difficulty index, facility index, discrimination power, internal consistency and biserial correlation. Central tendencies, standard deviation, grade norms, T - score, Percentile score, Standard scores, Z - score and Stanine score were the common norms established in the review studies. Validity of the tool was assured by correlating scores of the test with the scores obtained in the annual examination (correlational method) and with teacher's rating for pupils (ranking method). Validity coefficients were calculated for content, construct, concurrent, predictive, cross- validly and empirical validity. In some of the studies, validity was established in the beginning or during the procedure through experts' feedback for the tool constructed. Reliability was tested with the help of split half method, test - retest method, rational equivalence, Kuder -Richardson formula, Spearman - Brown formula, Rulon's formula. After the tool was administered for the stated objectives of the studies, data was analyzed in terms of normality check for distribution of the data. Hypotheses were tested with the help of Analysis of Variance, Product - moment correlation, Biserial correlation and formation of Regression equation. Factor analysis was done with Thurston's Centroid formula.

It has been shown that academic achievement and achievement in science have positive correlation with scientific attitude. Higher the achievement in science, higher will be the scientific attitude of the students. Hence, students' scientific attitude can be predicted from their achievement. With regard to experimental studies, it is prominent that all the studies showed significant difference between the performance of experimental group and control group. Additionally, the experimental groups seemed to be benefitted by the treatment they received. It can be said that any unconventional method has the ability to provoke students thinking. Some prominent points to be drawn from the reviewed studies are that achievement in science plays an important role as a determinant of scientific attitude, scientific aptitude, effectiveness of any new method or approach of teaching science and students' higher order ability.

For deciding upon the variables for the present study, following statements should be pondered upon. None of the researchers but Raveendranatham (1983) compared students' performance with regard to medium of instruction. Sex wise students did show significant difference in their performances. Except Ansari (1984), no other studies examined whether types of school affects

students' performance. Therefore, sex, medium of instruction and type of school become the essential variables for the present study.

The last study conducted on test construction and standardization was by Ghosh (1985). It is to be noted that no any similar studies have been conducted in recent times. With regard to test construction, almost all the studies have tried to determine students' performance at lower levels of cognition. Therefore, there is a dire need of constructing and standardising a test which covers lower as well as higher levels of cognition. Moreover, all the studies conducted in India as well as abroad have utilised Bloom's taxonomy for cognitive domain (1956) as a theoretical framework. Hence, it is obvious that the taxonomy has been serving as one of the most popular tool at various areas and various levels of the education process since its conception till present day. The same taxonomy can serve as a foundation for tool construction for the present study.

With regard to the location of the research studies conducted, it is prominent that either urban area or central parts of the states were the places where the reviewed studies were conducted. None of the reviews studied attempted to consider remote areas or deprived areas as the location of the studies. In the context of Gujarat state, there are many districts that are still unexplored and need to find a place in various research activities.

The implications drawn from the review of related studies helped researcher design the methodology for the present study. Chapter three depicts the details of the methodology adopted.