CHAPTER - VII

SUMMARY, CONCLUSIONS AND SUGGESTIONS

INTRODUCTION

This study was motivated by three main objectives. First, it was intended to identify chemistry laboratory skills at class XII in the senior Secondary Schools of the Union Territory of Delhi. The second objective was to construct tests which would measure the achievement of students in the chemistry laboratory skills (CLS) at the beginning and at the end of the academic session covering class XII. Our third objective was to find the effect of factors such as type of school, sex, type of examination, socio-economic status, and out of school activities on the development of Chemistry laboratory skills.

Other concerns of the study were as follows: How chemistry laboratory skills are related to theory knowledge, chemistry practical score in class XII (CBSE) examination and Chemistry theory score in class XII (CBSE) examination. How manipulative skills of a student are related to his cognitive skills; how manipulative skills of entry level test are related to manipulative skills of terminal level test; and, how cognitive skills of Entry Level Test are related to cognitive skills of terminal level test.

Statistical analysis was undertaken to answer many of the research questions raised in this study. This analysis consists primarily of the application of three techniques, namely, t-test, analysis of variance and correlation analysis.

Conclusions Regarding Research Questions

Research question No.1 asked "what are the basic skills needed and developed in class XII of the senior secondary school chemistry laboratory?" The list of the skills that were identified and finally selected for classes XI and XII are discussed in Chapter IV. These skills were categorised into eight major categories in each test. They were further sub-divided into 34 sub categories in the case of entry level test and into 41 sub-categories in the case of terminal level test.

Research question No.2 asked "Can tests be developed to measure achievement of these skills?" The very fact that these tests have been constructed and used in class XII of senior secondary stage chemistry laboratory prove that they can be developed. However, one could not accept nor use those tests without further evaluation. The test construction effort was apparently successful as will be seen by examining the findings of question No.3 that follows. But, in answer to the above question it would be important to report the comments of students and

teachers. Most of the chemistry teachers from schools/ colleges/universities/and science education specialists expressed the belief that chemistry laboratory skill tests filled a long felt void in test availability. The tests provided teachers with means to evaluate achievement of chemistry laboratory skills and also provided them with a test instrument that could be used for diagnostic purposes if so desired. A student of Chemistry is generally under the belief that by doing practicals in a chemistry laboratory and then appearing in the practical examination, he has learnt every skills of a chemistry laboratory. Teachers are also under a similar impression. They are hardly aware of how many chemistry laboratory skills they lack. It is in this context that these tests can be used for identifying the deficiencies of chemistry laboratory skills in a particular student. Some students also remarked that they enjoyed taking the laboratory skills tests mainly because it provided them a chance to perform a task in the laboratory so different from the usual laboratory work and to learn something new. They also felt that the experience was interesting and unique.

Research question No.3 asked "What are the characterstics of such tests?" in reference to the research instruments to measure chemistry laboratory skills. Content validity of the tests (Entry Level Test, Terminal Level Test,

& Theory Test (Pandit) was determined by asking a panel of knowledgable and experienced science educators, and senior secondary/College/University Chemistry teachers to indicate their agreement with the match of test-item and the skill it was designed to measure.

A copy of the chemistry practical syllabi of classes XI and XII was also supplied with the tests, category of skills and validation forms. Their responses which are discussed in Chapter IV, indicates an overwhelming agreement that tests are characterized by high content validity. A good number of questions received one hundred percent agreement and the rest received over eighty percent agreement from all those contacted. Several test-items also evoked suggestions and recommendations. Those recommendations and other critical remarks were taken into account while preparing the final version of the chemistry laboratory skill tests.

The reliability of various tests in total sample are given in table 7.1 below.

Table 7.1 - Reliability values of various tests

Tests	Total sample
Entry Level Test	0.410
Terminal Level Test	0.647
Theory Test (Pandit)	0.902

The inclusion of 17 test items that have low item difficulty is largely responsible for the value not being higher in the case of Entry Level Test. The inclusion of 13 test items that have low item difficulty is largely responsible for the value not being higher in the case of Terminal Level test. The reliability of the theory test (pandit) is very good. The inclusion of such items in the test is appropriate because they measure important laboratory skills. For this reason it is appropriate that students should have opportunity to demonstrate their mastery of these skills.

Examination of the individual item statistics reveals that some of them have low difficulty and likewise low discrimination values. Many of them were from both categories (manipulative & cognitive) of tests. The discrimination indices of the test-item lie between 0.100 and 0.300. These values reflect the degree to which the question discriminates between the better & poorer students. A high value reflects a question of greater discriminating power. The complete item analysis for each item in the tests is given in chapter V.

Research question No. 4 pertained to the relative performance of students on Entry level test, terminal level test and Theory test (Pandit) "The performance of students on various tests are given in table 7.2 overleaf.

Table 7.2 : Performance of Students on various tests

S. No.	Tests	Mean	Standard Deviation
1.	Entry Level Test	68.77	8.38
2.	Terminal Level Test	72.46	10.52
3.	Theory Test (Pandit)	61.52	22.96

These values clearly indicate that students have developed sufficient Chemistry laboratory skills needed for the completion of the Chemistry practical course of class XI. On an average a student has scored 68.77 marks out of 100. These values also indicate that there is sufficient gain in chemistry laboratory skills during the year. A student has on an average gained 3.69 marks. The correlations between Entry Level test and Terminal Level test, Between Terminal level test and theory (Pandit) test, Between Theory test and Entry level test are also highly significant.

Research question No.5 asked "about the relative performance of students on various tests from different types of schools". The students in some schools do differ in achievement on Entry Level test, and Terminal Level tests. The Entry level test performance differences between type I and type II school are not significant but they are significant between Type II school & Type III school and between Type III school and type I school. Thus type III school is distinctly different from the other two in this regard. The Terminal Level test performance

differences between Type I school and Type II school, between type II school and type III school and between type III school and type I school are all significant. But again, type III school shows its distinctiveness here also.

The Bogs and Girls of Type I school do differ on Entry Level Test. The boys and girls of type II school do not differ on Entry Level Test. The two groups of boys of Type I school & Type II school do not differ on Entry Level Test. The two groups of Girls of Type I school and Type II schools do differ on their achievement on Entry level test.

The Boys and girls of type I school do not differ on their achievement of Terminal level Test. The boys and girls of type II school do differ on their achievement of terminal level test. The two groups of boys of Type I & Type II schools do not differ on their achievement of Terminal level test. The two groups of girls in type I & type II schools do differ on their achievement of Terminal level test. It is important to note that in ELT it is girls of school type I who have distinctly lower score than the rest. But in TLT it is girls of type II school who have distinctly higher score than the rest.

Research question No.6 asked about the "correlation between laboratory skills (Entry level test, Terminal Level Test) and theory test (Pandit)". The correlation between Entry level test and theory test (Pandit) is significant in the total sample but not significant within various types of schools. The

correlation between Terminal Level Test and Theory Test (Pandit) is significant in the total sample but not significant in the three types of schools. The major variations in this context seem to be captured by school types. Variations within schools have no systematic pattern. This result also carries over to the next question.

Research question No.7 pertained to the "Correlation between chemistry laboratory skills (Entry Level Test and Terminal Level Test) and socio economic status. In the total sample this correlation is significant but not significant in the various types of schools.

Research question No.8 asked about the "Correlation between chemistry laboratory skills (Entry Level Test and Terminal Level Test) and out of school activities. The correlation between Entry level test and out of school activities (hobbies/scientific activities/Work experience/Vocational Job) is significant in the total sample and type I and type II schools and in the case of type III school (at 5% only). The correlation between Terminal level test and out of school activities is not significant in any of the four samples.

Research question No. 9 is intended to examine the correlation between Entry level test and Terminal Level Test. The correlation between Entry Level Test and Terminal Level Test are significant in all the four samples.

Research question No. 10 pertains to whether the correlation between chemistry laboratory skills (Entry level test, Terminal level test) and the chemistry practical score of class XII (CBSE). The correlations of Entry level test with chemistry practical score class XII (CBSE), is not significant in the total sample and also in three types of schools. The correlations of terminal level test with chemistry practical score class XII (CBSE) is not significant in all the samples.

Research question No.11 asked about the correlation between theory test score (Pandit) and theory test score class XII (CBSE)". The correlation of theory test score (Pandit) with theory test score class XII (CBSE) is significant in the total sample, Type I & Type II schools but not significant in the case of Type III school.

Research question No.12 is concerned about the correlation of manipulative skills and Cognitive skills of Entry level test. The correlations between the manipulative skills and Cognitive skills of Entry level test are not significant in any of the four samples.

Research question No.13 asked about the "correlation of manipulative skills and cognitive skills of Terminal level test." The correlation between manipulative skills and cognitive skills of Terminal level test is not significant in any of the four samples.

Research question No.14 pertained about the "correlation of manipulative skills of Entry level test and manipulative skills of Terminal level test." The correlation between the manipulative skills of Entry level test and manipulative skills of Terminal level test is not significant in the total sample, type II and type III schools sub samples. However the correlation is significant in the case of Type I school sub sample.

Research question No.15 asked about the "correlation of cognitive skills of Entry level test and cognitive skills of Terminal level test." The correlation between the cognitive skills of Entry level test and cognitive skills of Terminal level test is significant in the total sample and significant in the case of Type II & Type III schools at 0.05 level of significance only. The correlation in the case of Type I school is not significant.

Research question No.16 asked about the "correlation of various tests (ELT, TLT, Th.T), and the types of Examinations". The correlation between the various tests (ELT, TLT, & Th.T) and type of Examinations are significant in the total sample but the correlation cannot be computed in case of various types of schools, since the type of examination within a school is the same.

(B) Conclusion of the Study

The study has demonstrated that it is possible to construct tests of chemistry laboratory skills that are characterized by high content validity and apparently acceptable reliability. These tests may be used by schools to measure the achievement of their students in chemistry laboratory skills. They offer several advantages over skill tests prepared by teachers for their own use. These advantages include the use of greater number and variety of test items. Uniformity of tests that allows comparison within and between schools, sex, type of examination, socio-economic status, achievement in out of school activities, achievement in chemistry theory class XII (CBSE) achievement in chemistry practicals class XII (CBSE). The flexibility to use the results in an evaluative or diagnostic mode, as well as others that relate to individual school/teacher needs. The procedures used in constructing the tests are applicable to the construction of laboratory skill tests in areas of science other than Chemistry.

The capability of these laboratory skill tests to measure areas of learning other than the traditional content area was demonstrated and as such lends further credence to their use in evaluating a students performance in chemistry. The enthusiastic reception by both teachers and students lends additional support to their use.

Students appearing in the All India Higher Secondary Examination were found to perform significantly higher on tests of chemistry laboratory skills compared to students appearing in Delhi Board. The performance on the manipulation test-items was greater than on the cognitive based items. The significant effect due to sex, and type of school, was examined and several explanations were presented to account for these findings.

The study also revealed a high correlation between the ability to learn subject matter content and the ability to learn either manipulative or cognitive based laboratory skills. Again possible explanations were presented. This study concludes with recommendations for future studies that need to be pursued to answer some of the questions presented in discussion of the findings of this study as well as others raised in the literature.

(C) Suggestions for Future Studies

The following suggestions for additional studies are based on the findings of the present study as well as related review of literature. The suggestions are as follows:-

1. Additional tests of laboratory skills for other areas of science need to be developed, utilizing the Entry Level & Terminal Level tests of skills.

2. The Terminal Level Test of laboratory skills" should be used to establish local or national norms for achievement of chemistry laboratory skills as is true for subject matter content at various stages of school education.

3. The correlation between performance on the Entry level & Terminal Level tests of chemistry laboratory skills and other instruments that measure process of science needs to be established. In addition the correlation between performance on the Entry level test and Terminal level test of laboratory skills" and more specialised skill test needs to be determined.

4. Further studies need to be conducted to determine the specific characteristics of a curriculum that are responsible for promoting higher level of skill learning. The "Entry level test and Terminal level test of chemistry laboratory skills" would serve as the Criterion instrument.

5. Further studies need to be undertaken to determine which teacher and student characteristics lead to more effective teaching/learning of chemistry laboratory skills.

6. Additional research needs to be carried out to determine the influence of achievement in chemistry laboratory skills on final chemistry score in theory and practicals.

7. Investigations need to be carried out to determine the most effective way to teach/learn chemistry laboratory skills to students of different ability levels and interests.

8. Results from earlier studies concerning the importance of the laboratory to a science course need to be reexamined by employing a more appropriate criterion instrument such as the "Entry level test & Terminal Level test of chemistry laboratory skills."

9. Some other possible areas of study in the field of chemistry laboratory skills for consideration of future researchers are :

- Various curricula-related chemistry laboratory skill tests
- Chemistry Laboratory skill tests in different cultures, countries, regions, states etc.
- Chemistry Laboratory skill tests related to various Boards of Secondary Education.
- Chemistry Laboratory skill tests for handicapped and normal students.
- Chemistry Laboratory skills tests taking into account the time factor for achievement of skills.
- Chemistry Laboratory skill tests for urban and rural students.
- Chemistry Laboratory skill tests for students studying Chemistry/Science through various mediums of instruction (Language).

- Chemistry Laboratory skill tests using various strategies of instruction, language, work sheets, computer assisted instruction, programme - learning instruction, self paced instruction, individual performance, group performance, Individually guided system of instruction etc.
- Chemistry Laboratory skill tests for various socio-economic stratas.
- Chemistry Laboratory skill tests for various intelligence groups.
- Chemistry Laboratory skill tests for students with different material facilities/human support for learning in laboratory.

The suggestions can be probably many more keeping in view the nature of the area of study and the advances which have taken place in the developing countries particularly United States of America.

The development of tests to measure achievement of chemistry laboratory skills has made it possible to examine the chemistry laboratory experience in more detail. Several studies relating to chemistry laboratory skill achievement have been conducted and the results of these studies indicate that there is a difference in the ability of different curricula to promote achievement of laboratory skills. (See Review of literature Chapter II).

The studies also indicate that there is no difference in the ability of either males or females to learn chemistry laboratory skills. The Entry level test and Terminal Level test of chemistry laboratory skills developed in this study could be used to investigate additional research questions as recommended above. The answers to these questions will provide insight into the role of chemistry laboratory in promoting chemistry laboratory skills and the effect of different teacher-student characterstics and instructional strategies in achieving the goals of laboratory instruction.