CHAPTER 5
SUMMARY AND CONCLUSIONS
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5.1.0 RESTATEMENT OF THE PROBLEM

The changes in the educational system like changes in curricula should be based on research results. As the curriculum plan is implemented through the medium of instruction, it is important to study and understand how an intended curriculum is implemented, how it becomes operational and what factors affect its effectiveness. Such an understanding will not only provide information needed for improving the curriculum, but also provide scope for operating upon factors that make it further effective.

Polytechnics in India, provide education and training in various branches of engineering to prepare technicians. As Chemistry, Physics and Mathematics provide the foundation needed for the preparation of technicians, these three subjects have been included as 'Service Courses' in the curriculum of Diploma courses in Engineering.

The problem chosen for the present study has been to analyse the effectiveness of the chemistry curriculum of Diploma courses in Engineering offered by the polytechnics in the state of Tamil Nadu.

Chemistry is taught only during the first year of the Diploma courses in Engineering which are of three years duration. During the first year, students of various Engineering branches undergo a common programme of study in the subject chemistry
which includes theory and practicals. In the study conducted, the effectiveness of this curriculum in chemistry has been analysed.

The following were the OBJECTIVES of the study.

(1) To determine the extent to which the objectives of the polytechnic chemistry curriculum are achieved by the students.

(2) To identify the factors influencing the effectiveness of the chemistry curriculum.

(3) To judge the relative contribution of each of the objectives or cluster of objectives of the curriculum to its total effectiveness.

(4) To suggest changes to be made in the curriculum to make the "second generation programme" more effective.

5.2.0 SUMMARY OF RESEARCH DESIGN

5.2.1 THE APPROACH

The design of the study which was analytical and discriptive in nature closely followed the objectives of the study. The three main stages of the study which reflect the approach to the study are briefly highlighted below:

(i) Objective-wise assessment of effectiveness of the Chemistry curriculum:

For this purpose Criterion Referenced Tests (CRTs) based on a representative sample of the objectives of the curriculum, were constructed and used. Based on the performance of students in the CRTs, effectiveness of each of the curricular
objectives was determined in terms of the percentage of students achieving each objective.

As an index of the total effectiveness of the curriculum, gain percentage between post-test performance and pre-test performance (McGuigan and Peters, 1965) was calculated. To judge the relative contribution of each cluster of objectives of the curriculum to its total effectiveness, objectives of the curriculum as well as the CRTs representing them were classified into eight clusters based on Bloom's Taxonomy (1956). The actual contribution made by each cluster of objectives to the total effectiveness of the curriculum when compared with the possible contribution revealed which objectives were emphasized more (during curricular implementation) at the expense of other objectives. This stage gave an understanding of relative contribution objective cluster wise.

ii) Identification of the factors influencing the effectiveness of the curriculum

A total of nineteen factors were expected to influence the effectiveness of the chemistry curriculum under consideration. The hypothesized factors were classified into three groups as shown below.

(A) Factors related to the Student: The nine hypothesized factors in this group were: Chemistry aptitude, Proficiency in Engineering subjects, Sex of the student, Proficiency in Science in the previous course, Proficiency in English language, Intelligence, Student preparedness, Student motivation and Student involvement.
(B) Factors related to the Teacher: The two factors hypothesized in this group were: Teacher preparedness and Teacher's resourcefulness.

(C) Factors related to the Instructional environment: The eight factors hypothesized in this group were: Appropriateness of objectives, Adequacy of instructional time, Instructional resources, Instructional methods and procedures, Task orientation of the class, Order and organisation of the class, Evaluation procedures used and Feedback provided to students.

Each hypothesized factor was represented in the study by at least one variable. A total of thirty variables representing 17 out of the 19 hypothesized factors were included in correlational analysis. To identify the factors influencing the effectiveness of the curriculum the intercorrelation matrix of these 30 variables was subjected to factor analysis. Factors extracted were identified and variance contribution percentage was estimated. This stage further gave an understanding of factor-wise relative contribution.

For two of the hypothesized factors viz., student motivation and student involvement, the data required was collected from teachers. To study the relationship between teachers' objective-wise preception of each of these two dimensions and the effectiveness of the objectives of the curriculum as measured by the percentage of students who have mastered each of the objectives, the test of significance of the difference between two correlated proportions was carried out.
(iii) Identification of the changes to be made in the curriculum

Based on the multiple perspectives obtained by analysing the data collected from various information sources and by analysing the chemistry syllabus, the changes to be made in the curriculum to make the second generation programme more effective have been suggested.

5.2.2 SAMPLE

Three polytechnics in the city of Madras, capital of Tamil Nadu state, provided the sample for the study. The multiphased data collection and intensive analysis required a sample incidental and handy, and occurring in its best natural condition.

The sample for the study consisted of

(i) Two hundred and sixty seven students undergoing the first year of the Diploma courses in Engineering in five classes, at three polytechnics in Madras (during the academic year 1984-85). Of this sample 56.55% (N=151) were boys and 43.45% (N=116) were girls.

(ii) Five teachers of Chemistry who taught the students constituting the sample.

Though the original size of the sample was 267 students (in the begining of the academic year) when the study came to completion, data on 234 students only were available on all the variables. It is this data that has been employed in this study.

Besides students and teachers, subject experts, Polytechnic records of examination marks and the curriculum document provided the information required for the study.
5.2.3 INSTRUMENTS USED

The following instruments have been developed and used in the study:

1. Student Information Blank which enabled collection of information about students' educational background.

2. Criterion Referenced Tests (CRTs) in Chemistry which made objective-wise testing possible.

CRTs were used to determine the extent to which the objectives of the curriculum are achieved by the students.

As the curriculum document does not specify the objectives to be achieved, a comprehensive list of objectives were prepared and validated. The validated list contained 218 objectives. From this list, 46 objectives were selected by 'Domain sampling' technique (Hively et al. 1973) as a representative sample of the curriculum. Forty six CRTs, one for each of the objectives selected, were developed. These 46 CRTs constitute a battery of CRTs. Each CRT was either four or six items long.

All the 46 objectives/CRTs taken together, the test battery tested eight clusters of objectives under Bloom's Taxonomy (1956) and was 214 items long. All CRTs which measure the same category of behavioural ability in the Bloom's Taxonomy constitute a sub-test. The 46 CRTs were grouped into eight sub-tests based on the ability tested by them.

The mean correlation of a sub-test with the other sub-tests in the same battery serves as an index of Discriminant Validity of the particular sub-test. The Discriminant Validities of the eight sub-tests in the battery of CRTs range from 0.20 to 0.47 with a grand mean of 0.34.
Concurrent Validity of the CRT-test battery against polytechnic chemistry theory examination is 0.45.

Subkoviak's Group coefficient of Agreement (1976) which is an estimate of the proportion of students in a group that are consistently assigned to the same mastery state, is a very good measure of the reliability of a criterion referenced test.

The reliabilities of the 46 CRTs as determined by Subkoviak's Group coefficient of Agreement range from 0.54 to 0.95 with a mean value of 0.77.

(3) Pre-Test in Chemistry which enabled an objective-wise assessment of students' performance prior to instruction i.e., in the beginning of the academic year.

The Pre-test was an assembly of 60 items selected from the items constituting the 46 CRTs representing the 46 objectives. Each objective of the curriculum was represented in the pre-test by either one or two items.

(4) Instructional Environment Rating Scales which enabled rating of Instructional Environment on 10 and 11 dimensions by the students and teachers respectively.

The two instruments called Instructional Environment Student Scale (IESS) and Instructional Environment Teacher Scale (IETS) provided for topicwise rating of the instructional environment.

(i) Instructional Environment Student Scale (IESS)

The IESS contained a total of 40 items relating to 10 instructional environment dimensions viz., Student preparedness, Adequacy of instructional time, Teacher preparedness, Instructional resources, Instructional methods and procedures,
Teacher's resourcefulness, Task orientation of the class, Order and organisation of the class, Evaluation procedures used and Feedback provided to students. The number of items constituting each scale ranged from 2 to 7. The students had to express their extent of aggreement or disaggreement with each item on a four point scale, considering the atmosphere that prevailed in the class at the time of teaching a particular topic in Chemistry.

The discriminant validity i.e., mean correlation of a particular scale with the other scales in the IESS ranged from 0.40 to 0.58 with a grand mean of 0.49 for the 10 scales in the IESS (N = 234 individual students). The internal consistency reliability (Cronbach's Alpha coefficient (1951)) ranged from 0.60 to 0.84 with a mean of 0.71 for the 10 scales in the IESS.

(i) Instructional Environment Teacher Scale (IETS)

The IETS contained a total of 43 items relating to 11 instructional environment dimensions. The IETS contained nine of the ten dimensions in the IESS (exception being the dimension titled 'Teacher's resourcefulness'). In addition to these nine dimensions the IETS contained two more dimensions named 'Student motivation' and 'Student involvement'. The number of items constituting each scale ranged from 2 to 6. The mode of responding to the IETS was the same as in the case of the IESS.

The internal consistency reliability (Cronbach's Alpha Coefficient (1951)) based on a sample of 5 teachers ranged from 0.66 to 0.92 with a mean of 0.78 for the eleven scales in the IETS.
The Concurrent Validity of the IETS was estimated using the scale scores of the IESS as the criterion measure. Spearman's Coefficient of rank correlation between the mean per item of the nine scales which are common both in the IETS and IESS was found to be 0.67 which is significant at .10 level (Two tailed test).

(5) Chemistry Objectives Rating Scales which were developed to assess students' and teachers' perceptions of the appropriateness of curricular objectives.

The Chemistry Objectives - Student Rating Scale provided for rating, on a three point scale, each of the 46 objectives of the curriculum on two dimensions. viz., Usefulness and Difficulty level. The reliability estimate of these two variables obtained as communalities in the Factor analysis are 0.51 and 0.54 respectively. (cf.Table 4.1). The Chemistry Objectives - Teacher Rating Scale is similar to the student scale.

(6) Dimensional Rating Scales of Student's Psychomotor Skills and Affective Behaviours which provided for teacher rating of individual students on their performance of psychomotor skills and affective behaviours in chemistry.

Teacher had to rate every student in his class with respect to each of six dimensions (Three dimension of Psychomotor skills and Three dimensions of Affective behaviours) on a numerical rating scale of 1 to 5.

The reliability estimates of these two variables viz. Teacher assessment of student's (i) Psychomotor skills and (ii) Affective behaviours in Chemistry, obtained as Communalities in the Factor analysis are 0.73 and 0.72 respectively.
Besides the above instruments developed by the researcher, the following instruments were also used in the study.

(7) Raven's Standard Progressive Matrices (SPM)

For assessing student's intelligence Raven's Standard Progressive Matrices (Raven, 1958) which is a non-language and culture free test was used.

The reliability estimate (Obtained Communality) of this test is 0.72, which is in agreement with earlier reported estimates.

(8) Question papers used in polytechnic examinations in the following five subjects have a deemed status as instruments used in the study, as students' scores in these examinations have been used as variables in the study:

Chemistry theory, Chemistry Practical, English, Engineering drawing and Workshop practice.

The reliability estimates (obtained communalities) of these five measures ranged from 0.54 to 0.73 with a mean of 0.63.

5.2.4 PROCEDURES USED IN THE COLLECTION OF DATA

The data required for the study was collected in six phases spread over one academic year i.e. during the ten month period from August, 1984 to May, 1985. The activities carried out during each of the six phases of data collection are briefly described below.

Phase I

During the first month of the academic year information about students' background was collected using student Information Blank. Also, the pre-test was administered to the students.
Phase II

During the fourth month of the academic year the following activities were completed.

(1) Administering the first set of CRTs to students (The 46 CRTs were administered in three sets in respectively three stages spread over one academic year. Each set of CRT was based on the topics covered during the three months period preceding its administration)

(2) Collection of data from students and teachers using Instructional Environment Rating Scales for the topics covered by the first set of CRTs.

Phase III

Raven's Standard Progressive Matrices was administered to the students during the middle of the academic year (i.e. during the fifth month) in order to assess their intelligence.

Phase IV

During the sixth month of the academic year, the second set of CRTs was administered to the students. Further, using Instructional Environment Rating Scales data for the topics covered by the second set of CRTs was collected from students and teachers.

Phase V

During the ninth month of the academic year the following activities were completed

(1) Administering the third and last set of CRTs to the students

(2) Collection of data from students and teachers using Instructional Environment Rating Scales for the topics covered by the third and last set of CRTs.
(3) Collection of data from students and teachers using Chemistry Objectives Rating Scales.

(4) Collection of data from teachers using Dimensional Rating Scales of Student's Psychomotor skills and Affective behaviours in chemistry.

Phase VI

During the last month (i.e. the 10th month) of the academic year, students' marks in the examinations conducted by the polytechnics, were collected from the records of the polytechnics.

The entire work of collecting data from the students and teachers of five classes at three polytechnics, was done by the researcher himself. This ensured uniformity in providing directions during the administration of various tests and other instruments and also established a good rapport between the researcher and respondents. Such a rapport was very useful in collecting the data required for this multiphased and intensive study.

5.2.5 DATA ANALYSIS

The data analysis carried out, closely followed the objectives of the study. The analytical techniques used in the various stages of data analysis are highlighted in this section. All major analyses were carried out using a computer - IBM 360/44.

(1) The performance of students in the pre-test was analysed objective-wise in order to identify the objectives in which
the students were proficient even before instruction commenced.

(2) An index of total effectiveness of the curriculum was calculated in terms of Gain percentage between post-test performance and pre-test performance.

(3) To judge the relative contribution of each cluster of objectives of the curriculum to its total effectiveness, the gain percentage, possible contribution percentage and actual contribution percentage for each of the eight clusters of objectives of the curriculum were computed.

(4) To determine the extent to which the objectives of the chemistry curriculum are achieved by the students, performance of individual students in each of the 46 CRTs were considered. In each CRT, students who have secured a score equal to or above the cut-off point specified were classified as masters. Further, an objective which has been mastered by atleast 51% of the students was considered a mastered objective. By applying this criterion the objectives which have not been mastered were identified.

(5) The data collected from the students through the Instructional Environment Student Scale was analysed, using the individual student as the unit of analysis. Besides the descriptive statistics and scale validation statistics for each scale of IESS, the following statistics were computed.

(i) Mean and S.D of the scale scores of students for each of the ten scales in the IESS for each of the 21 topics in the curriculum.
(ii) Mean and S.D. of the sum (summed over 21 topics) of the item scores of students for each of the 40 items in the IESS.

(iii) Sum (Summed over 21 topics) of the scale scores of individual students for each of the ten scales in the IESS. These measures have been used as ten variables in the Factor analysis carried out.

(6) With a view to study the relationship among the variables operating on the curricular scene, correlations (Pearson r's) among the 30 variables were computed and an intercorrelation matrix was constructed.

(7) To identify the factors influencing the effectiveness of the curriculum, the intercorrelation matrix of the 30 variables was subjected to Factor analysis. A principal component solution of the intercorrelation matrix, followed by varimax rotation of the factor matrix was performed. In order to keep the number of independent dimensions as small as possible Kaiser's (1958) Varimax criterion was used. i.e., only those eigen values greater than or equal to 1.0 were retained in the analysis.

(8) The data collected from the teachers (N=5) through the Instructional Environment Teacher Scale was analysed using the individual teacher as the unit of analysis. Besides the descriptive statistics and scale statistics of the scales in the IETS, mean and S.D. of the sum (summed over 21 topics) of the item scores of teachers for each of the 43 items in the IETS were computed.
(9) To study the relationship between teachers' and students' perceptions of the same dimensions of the instructional environment, Spearman's coefficient of rank correlation between the nine scales which are common in both the IESS and IETS was calculated.

(10) To study the relationship between teachers' objective-wise perception of (i) Students' motivation and (ii) Students' involvement and the effectiveness of the objectives of the curriculum as measured by the percentage of students who have mastered each of the objectives, the test of significance of the difference between two correlated proportions (Ferguson, 1966, p.178-181) was carried out.

(11) Students' ratings of the 'usefulness' and 'difficulty level' of the objectives were included as two variables in the factor analysis carried out. In order to determine whether teachers' ratings of the objectives and students' ratings differ significantly, the test of significance of the difference between two correlated proportions was carried out.

(12) To identify the appropriate sequence in which the topics in the curriculum are to be taught, the syllabus in chemistry given in the curriculum document was analysed using Network analysis technique (Wyant, 1973).

5.3.0 PRINCIPAL FINDINGS, CONCLUSIONS AND IMPLICATIONS
5.3.1 PRINCIPAL FINDINGS

The following are the principal findings of this study.

(1) Objective-wise analysis of the performance of the students
in the pretest revealed that the students had not mastered any of the objectives of the polytechnic chemistry curriculum in the beginning of the academic year.

(2) The total score of students on the battery of CRTs was normally distributed.

(3) Total effectiveness of the curriculum calculated in terms of Gain percentage between post-test performance and pre-test performance was 50.58%.

(4) Regarding the relative contribution of each cluster of objectives of the curriculum to its total effectiveness it was found (i) Objectives representing the lowest category of ability in Bloom's Taxonomy viz. Knowledge contribute more to the total effectiveness of the curriculum than what is just possible when compared to objectives representing higher order abilities like Comprehension and Application. This implies 'Knowledge' objectives are being emphasized at the expense of 'Comprehension' and 'Application' objectives. (ii) Objectives of chemistry practicals contribute more to the total effectiveness of the curriculum than what is just possible when compared to the objectives of Chemistry theory.

(5) Only fifty seven percent of the objectives of the curriculum were effective in the sense that they have been mastered by the students.

(6) All the objectives in three topics viz., 'Periodic Table', 'Acids, Bases and Salts' and 'Valency' have not been mastered by the students. About two thirds of the
objectives in each of the three topics viz., 'Equivalent weight', 'Solutions' and 'Water' have not been mastered.

(7) While about 81% of 'Knowledge' objectives have been mastered by the students, only 43.5% of the objectives representing higher order abilities viz., Comprehension and Application have been mastered. This implied that achievement of objectives representing higher order abilities was far from satisfactory.

(8) There was positive relationship between students' perception of the Instructional environment that prevailed while teaching a topic and the extent to which the objectives in the particular topic were mastered by the students.

(9) (a) In general, the Instructional environment of practical classes in chemistry was perceived by students to be better than that of theory classes.

(b) Teachers have provided appropriate examples while teaching the various topics of the curriculum.

(c) While teaching the various topics in the curriculum mostly lecture method has been used.

(d) Enough sets of apparatuses for individual experimentation by students were not available in the chemistry laboratories.

(10) There was a close positive relationship between teachers' and students' perceptions of the same dimensions of Instructional environment. In general teachers perceived a more positive Instructional environment than did their students in the same classrooms.
(11) A study of the correlations among the variables operating on the curricular scene revealed the following relationships.

(i) There was close association between student perception of Instructional environment and their curricular performance. This is evident from the fact that six out of the ten Instructional Environment Student Scale variables have significant correlations with CRTs in chemistry and Chemistry theory and practical examinations. The pattern of correlations observed provide enough evidence to say that Instructional environment plays an important role in influencing the effectiveness of the chemistry curriculum.

(ii) Students' proficiency in English language appears to hold the key in the instructional scene as it is the medium of instruction. This is evident from the following (a) Performance of students in Polytechnic English examination has significant correlations with half the number of Instructional environment variables and the IESS total, and (b) Performance of students in X standard English examination has significant positive correlations with most of the curricular performance variables. (cf. Table 4.11)

(12) Factor analysis of 30 variables carried out in order to identify the factors influencing the effectiveness of the curriculum led to the extraction of seven principal factors which account for 63.98% of the variance attributable to all the 30 variables. The name given to each factor and the
percent of variance explained by each factor from what is attributable to all the 30 variables is presented in Table 5.1.

**Table 5.1**

Factors influencing the effectiveness of the Chemistry curriculum and the variance explained by each of them.

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Name of the Factor</th>
<th>Percent of variance explained from that attributable to all the 30 variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Students' perception of teacher created instructional environment</td>
<td>18.84</td>
</tr>
<tr>
<td>2.</td>
<td>Engineering skill</td>
<td>12.55</td>
</tr>
<tr>
<td>3.</td>
<td>Chemistry aptitude</td>
<td>11.89</td>
</tr>
<tr>
<td>4.</td>
<td>'Students' perception of the appropriateness of curricular objectives</td>
<td>4.97</td>
</tr>
<tr>
<td>5.</td>
<td>Learning difficulties due to inadequate entering behaviour</td>
<td>5.11</td>
</tr>
<tr>
<td>6.</td>
<td>Verbal interpretation ability in English</td>
<td>6.13</td>
</tr>
<tr>
<td>7.</td>
<td>Nonverbal-verbal task Orientation</td>
<td>4.49</td>
</tr>
</tbody>
</table>

(13) In the factor analysis by virtue of association of most of the variables pertaining to chemistry with the third factor it has been identified as 'chemistry aptitude'. To judge the relative contribution of the various variables to the chemistry aptitude factor, the contributions (in terms of percent of variance explained) of each of the variables to
the total variance explained by the 'Chemistry aptitude' factor were computed. The results obtained revealed the following:

(i) Criterion referenced tests in chemistry (Five of them) taken together account for 9.14% of the total variance explained by the 'chemistry aptitude' factor. (One of the five CRTs viz., CRT on Extrapolation ability alone accounts for 4.40% of the total variance explained by 'Chemistry aptitude'). Chemistry theory and practical examinations conducted by the polytechnics taken together account for 23.77% of the total variance explained by 'Chemistry aptitude'. These two observations prompt a suggestion that the effectiveness of the present chemistry theory and practical examinations or the effectiveness of the operational curriculum can be increased by 38.5% of what it is today, if CRTs are also included in the system of evaluation in chemistry.

(ii) Teacher assessment of student's psychomotor skills and affective behaviours in chemistry taken together account for 37.82% of the total variance explained by 'chemistry aptitude'. This implies that there is a strong case for including teacher assessments of student's psychomotor skills and affective behaviours in the system of evaluation in chemistry.

(iii) Performance in polytechnic 'English' examination contributes to the extent of 7.55% of the total variance explained by 'chemistry aptitude'. This
confirms the important role played by English as the medium of instruction in the polytechnics.

(iv) Performance in polytechnic 'Engineering drawing' and 'workshop practice' examinations taken together account for 18.08% of the total variance explained by the 'Chemistry aptitude' factor. This reflects the aptitudinal basis chemistry furnishes perhaps also to Engineering drawing and Workshop practice which constitute. The measure of 'Engineering skill' identified as Factor 2.

(14) There was no significant difference between the proportions of curricular objectives having high values on the two dimensions viz., Teachers' perception of 'Students' motivation' and students' performance in the CRTs representing the objectives. A similar finding was obtained with respect to the teachers' perception of 'students' involvement'.

(15) There was no significant difference between teachers' rating and students' rating of the 'Usefulness' of the objectives of the chemistry curriculum. A similar finding was obtained with respect to the teachers' and students' rating of the 'Difficulty level' of the objectives.

(16) The curriculum document was found to be deficient in many respects. Analysis of the syllabus in chemistry using Network analysis technique enabled the identification of the appropriate sequence in which the topics in the syllabus are to be taught.
5.3.2 CONCLUSIONS

From the findings summarized in the previous section, the following conclusions have been formulated.

(1) Only 57% of the objectives of the chemistry curriculum were effective in the sense that they have been mastered by the students. In particular achievement of objectives representing higher order abilities is far from satisfactory. Further, total effectiveness of the curriculum calculated in terms of gain percentage between post-test performance and pre-test performance was only 50.58%. These findings indicate that there is lot of scope for increasing the effectiveness of the curriculum.

(2) (a) Objectives representing the lowest category of ability in Bloom’s Taxonomy (1956) viz., Knowledge contribute more to the total effectiveness of the curriculum than what is just possible when compared to objectives representing higher order abilities like Comprehension and Application. This implies 'Knowledge' objectives are being emphasized at the expense of 'Comprehension' and 'Application' objectives. (b) Objectives of chemistry practicals contribute more to the total effectiveness of the curriculum than what is just possible when compared to the objectives of chemistry theory. This implies that if the weightage assigned to practicals in the present curriculum is increased, effectiveness of the curriculum will be enhanced.

(3) There is a close positive-relationship between teachers' and students' perceptions of the same dimensions of
instructional environment. Further, there is no significant difference between teachers' rating and students' rating of the 'appropriateness' of the objectives of the chemistry curriculum.

(4) Among the seven factors influencing the effectiveness of the chemistry curriculum, 'Instructional environment' is the most crucial one (as it explain the highest percentage of the total variance),

(5) The modus operandi of Instructional environment appears to be the language (i.e., English) used as the medium of instruction. In the Polytechnics in Tamil Nadu as 61.42% of students change over from Tamil medium in High schools to English medium in the polytechnics, Students' proficiency in English language plays a very important role in influencing their achievement in chemistry. This is further confirmed by the fact that 'Verbal interpretation ability in English' has emerged as a factor influencing the effectiveness of the curriculum.

(6) A perusal of the relative contribution of various variables to the 'Chemistry aptitude' factor, indicates that the effectiveness of the present chemistry theory and practical examinations or the effectiveness of the operational curriculum can be increased considerably if Criterion Referenced Tests and Teacher assessment of student's psychomotor skills and affective behaviours are also included in the system of evaluation of student's performance in chemistry.
(7) The following four factors also influence the effectiveness of the chemistry curriculum: Engineering skill, Students perception of the appropriateness of curricular objectives, Learning difficulties due to inadequate entering behaviour, and Nonverbal - Verbal task orientation.

(8) The curriculum document was found to be deficient in many respects. Even the objectives of the curriculum have not been included in it.

5.3.3 IMPLICATIONS OF THE FINDINGS

Based on the multiple perspectives obtained from the findings of the study, changes to be made in the curriculum to make the "Second generation programme" more effective have been identified. A list of the changes recommended is given below.

1. The curriculum document should include detailed information on objectives of the curriculum, entering behaviour requirements, the order in which the topics are to be taught, instructional methods and resources, and scheme of evaluation. Provision of such detailed information in the curriculum document will reduce the gap between "intended curriculum" and "Operational curriculum".

2. For facilitating the learning of topics which are found to be difficult, adequate instructional time and highly structured instructional materials have to be provided. Further it should be ensured that the students possess the entering behaviour required for learning these topics.

3. The weightage assigned to practicals (compared to theory) in
the present curriculum may be increased to enhance the effectiveness of the curriculum.

4. Teachers have to take special efforts to improve the instructional environment inorder to facilitate attainment of objectives representing higher order abilities like comprehension and Application.

5. While revising the curriculum and developing the 'second generation programme' teachers of engineering disciplines should be consulted for selecting objectives in chemistry which will be useful and relevant to the students of engineering. Also experienced teachers of chemistry have to be consulted for deciding about the 'difficulty level' of the objectives proposed to be included in the curriculum.

6. As proficiency in English language, which is the medium of instruction in the polytechics, is found to be an essential prerequisite for learning of chemistry, it is necessary to organise in the polytechnics 'Bridge courses in English' particularly for students who had their previous education in Tamil medium. These 'Bridge courses' have to be conducted in the beginning of the academic year.

7. Instead of using mostly lecture method, teachers should use a variety of instructional methods. The instructional methods that are appropriate to each of the topics in the curriculum may be indicated in the curriculum document.

8. Steps should be taken to provide adequate laboratory resources needed for individual experimentation by students.

9. Teachers should make efforts to enhance the task orientation
of their classes in order to facilitate the development of (i) higher order abilities like 'Comprehension' and 'Application' and (ii) abilities and skills involved in chemistry practicals.

10. In the system of evaluation of students' performance in chemistry, criterion referenced tests and Teacher assessment of students' psychomotor skills and affective behaviours may be included to increase the effectiveness of the operational curriculum.

5.4.0 RECOMMENDATIONS FOR FURTHER RESEARCH

1. Using the Factors influencing the effectiveness of the chemistry curriculum identified in this study, further investigations may be undertaken employing techniques like multiple regression.

2. A study may be undertaken to explore whether each scale in the Instructional Environment Student Scale (an instrument developed in this study) is capable of differentiating between the perceptions of students in different classrooms, by preforming a one-way ANOVA with class membership as the main effect and using the individual as the unit of analysis.

3. To determine the topics and objectives in chemistry that are appropriate to the needs of the students of Diploma courses in various branches of Engineering, a study may be undertaken.

4. Micro-level evaluation of the curriculum of individual subjects prescribed for polytechnic courses may be carried
out following the design of this study. In particular the curricula of 'Physics' and 'Mathematics' which also serve as 'Service courses' in the programmes offered by the polytechnics may be evaluated.

5. The effectiveness of the Chemistry curriculum of Engineering Colleges (which are under the control of the Universities) may be analysed, by undertaking a similar study.

CONCLUSION

The study enabled the identification of the strengths and weaknesses of the chemistry curriculum of the polytechnics. All the four objectives of the study have been fully achieved. The study has provided valuable inputs for improving the chemistry curriculum by suggesting the changes to be made. This will enable the authorities concerned to make the "second generation programme" more effective. A battery consisting of 46 Criterion Referenced Tests in chemistry has been made available for the use of teachers of chemistry. The methodology employed in the development of criterion referenced tests is specially useful to researchers moulding their work in similar directions. As by-products of the study two instruments titled 'Instructional Environment Student Scale' and 'Instructional Environment Teacher Scale' have been made available for use by other researchers in the field of curriculum evaluation. It is hoped that the basic design of this study will serve as a prototype for microlevel evaluation of the curriculum of individual subjects of various courses.