Chapter V

SUMMARY AND CONCLUSION
# CHAPTER V

**SUMMARY AND CONCLUSION**

## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Contents</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CHAPTER V</td>
<td>201</td>
</tr>
<tr>
<td>C.</td>
<td>SUMMARY AND CONCLUSION</td>
<td>201</td>
</tr>
<tr>
<td>5.1</td>
<td>SCIENCE EDUCATION</td>
<td>201</td>
</tr>
<tr>
<td>5.2</td>
<td>SCIENCE EDUCATION IN INDIA</td>
<td>202</td>
</tr>
<tr>
<td>5.3</td>
<td>NEED FOR THE STUDY</td>
<td>204</td>
</tr>
<tr>
<td>5.4</td>
<td>SIGNIFICANCE OF THE STUDY</td>
<td>206</td>
</tr>
<tr>
<td>5.5</td>
<td>SCOPE OF THE STUDY</td>
<td>208</td>
</tr>
<tr>
<td>5.6</td>
<td>TITLE OF THE STUDY</td>
<td>208</td>
</tr>
<tr>
<td>5.7</td>
<td>OBJECTIVES OF THE STUDY</td>
<td>209</td>
</tr>
<tr>
<td>5.8</td>
<td>RESEARCH HYPOTHESES</td>
<td>209</td>
</tr>
<tr>
<td>5.9</td>
<td>METHODOLOGY OF THE STUDY</td>
<td>210</td>
</tr>
<tr>
<td>5.9.2</td>
<td>TOOLS USED IN THE STUDY</td>
<td>211</td>
</tr>
<tr>
<td>5.9.3</td>
<td>DESIGN OF THE STUDY</td>
<td>213</td>
</tr>
<tr>
<td>5.10</td>
<td>STATISTICAL TECHNIQUES EMPLOYED IN THE STUDY</td>
<td>216</td>
</tr>
<tr>
<td>5.11</td>
<td>FINDINGS OF THE STUDY</td>
<td>216</td>
</tr>
<tr>
<td></td>
<td><em>STAGE 2: DIAGNOSTIC TEST ANALYSIS</em></td>
<td>221</td>
</tr>
<tr>
<td></td>
<td><em>STAGE 3: ORIENTATION PROGRAMME – ANALYSIS OF ENTRY AND EXIT BEHAVIOUR OF TEACHERS</em></td>
<td>224</td>
</tr>
<tr>
<td></td>
<td><em>STAGE 4A: ANALYSIS OF IMPACT OF REMEDIAL TEACHING LEARNING MATERIAL</em></td>
<td>225</td>
</tr>
<tr>
<td></td>
<td><em>STAGE 4B: ANALYSIS OF IMPACT OF VARIABLES</em></td>
<td>225</td>
</tr>
<tr>
<td>5.12</td>
<td>DISCUSSION</td>
<td>227</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>5.13</td>
<td>EDUCATIONAL IMPLICATIONS AND RECOMMENDATIONS</td>
<td>231</td>
</tr>
<tr>
<td>5.14</td>
<td>RECOMMENDATIONS</td>
<td>233</td>
</tr>
<tr>
<td>5.15</td>
<td>SUGGESTIONS FOR FURTHER STUDY</td>
<td>234</td>
</tr>
<tr>
<td>5.16</td>
<td>CONCLUSION</td>
<td>235</td>
</tr>
</tbody>
</table>
CHAPTER V

SUMMARY AND CONCLUSION

"Education is the manifestation of the perfection already in man"

- Swami Vivekanand

Swamiji conceived an education system by which character is formed, strength of
the mind is increased, intellect is sharpened and by which one can stand on one’s own feet.He
felt that education is neither mere book learning nor acquisition of diverse knowledge, but
development of skills. This cannot be taught by anybody else; it can only be experienced and
internalized by the learner. All knowledge is within him and it requires only an awakening. This
is where the task of the teacher begins to help the learner ‘discover’ or ‘unveil’ what he already
knows. The teacher can motivate, demonstrate and persuade the learners to discover their own
potential and intellect to properly understand their body, mind and spirit. Mahatma Gandhi also
insisted that, “real education has to draw out the best from the boys and girls to be educated.
Packing ill-assorted and unwanted information into the heads of the pupils becomes a dead
weight crushing all originality in them and turning them into mere automata”.

5.1 SCIENCE EDUCATION

The word "science" means "knowledge." Science is more than facts and figures. Science
is a way of thinking and a way of understanding the world. Being ‘scientific’ involves being
curious, observing, asking how things happen, and learning how to find the answers.Science
adopts an empirical approach to the search for natural explanations of phenomena observed in the
universe. Science learning has two dimensions, namely learning about science and how to do
science:
'Learning about science' means 'to learn about the products of scientific inquiry, which includes facts, concepts, principles and theories'. 'Learning how to do science' means 'to pay attention to the process of science, to apply the process and inquiry skills that are typical of scientific thinking'.

Learning takes place when the students are actively engaged in an intellectual struggle. Knowing how they think helps the learner learn the concept well. Students learn better when teachers use a constructivist approach that involved teaching science in a variety of ways. Researches provide evidence that this instructional approach may be more useful in enhancing conceptual growth.

If science education is to be effective, the role of the teacher is to identify and encourage the curiosity, which is inherent in learners, and help them understand how to make sense of what they see. The basic procedure is to manifest the innate curiosity through guided procedures of learning science. Children learn science best and understand scientific ideas better if they are able to investigate and experiment. This can help children think critically and gain confidence in their own ability to solve problems. What is more important is conceptual understanding than factual knowledge.

5.2 SCIENCE EDUCATION IN INDIA

In India, science was made a compulsory subject for all children up to class X only in mid 50s. The National Policy on Education of 1968, which accepted the Kothari Commissions recommendations, made science a compulsory subject in the first ten years of school. This policy document also provided specific directions on science education as follows:

“Science education will be strengthened so as to develop in the child well developed abilities and values such as the spirit of inquiry, creativity, the courage to question our aesthetic sensibility. Science education programmes will be designed to enable the learners to acquire
problem-solving and decision making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life."

The Sixth All India Educational Survey identified that though the total enrolment in class I in India is 27.3 million, only 6.8 million wrote the public examination of standard X conducted by as many as 34 boards of school education. Of this student population, only 3.9 million went for senior secondary education. This colossal wastage of human effort is a sad reflection of the quality of education that our schools are able to provide to their pupils. This survey also identified a visible decline of interest amongst young persons in studying science at higher level. While several socio-economic factors including emergence of new field of activities, entrepreneurship and opportunities could be contributing factors of this state, the role of the school and the way science is taught and learnt cannot be ignored.

In many Indian schools the emphasis is still on rote learning of science. Textbooks are often the prime curriculum resource in schools and the only instructional tool available. There is a dearth of activities, quizzes, puzzles and other hands-on activities that can be easily performed and are meaningful for the student. There is less concretization of instructional materials through analogies, situations, problems and illustrations. The textbook ensures lots of facts and instills bits of information and students are not given chance to think.

Science by nature is interdisciplinary and integrated. But in the science textbook, the curriculum is compartmentalized into variety of disciplines and is treated as separate subjects. Teachers handling science normally interpret science according to their own area of specialization and do not view science holistically. Though teachers are graduated from colleges with degrees in Physics, Chemistry, Botany and Zoology, they are not trained to teach science in an integrated, holistic manner.

These practices do not provide opportunities for scientific investigation and experimentation. It therefore becomes much imperative to switch over from the lecture method.
to the problem solving, activity method, experimentation, demonstration and role play where there in true learning of science.

The aim of teaching science in secondary schools is not directed to the production of scientists. It is to give basic understanding and an appreciation of scientific phenomena, biological and physical, which may prepare the ‘non-scientists’ for a fuller and more complete life. It should also give fundamental principles to those relatively few who will specialize in science.

5.3 NEED FOR THE STUDY

Scientific discoveries and their applications in industry, communications, agriculture, medicine and wars have caused great changes in the lives of mankind. Science is no longer confined to a few seriously devoted persons. Since living in the present world invariably warrants, to variable degrees, knowledge of scientific facts and laws, science has now become everyday science for everybody. This general understanding of science must become part of everyone’s life and thought.

Teaching of science need to be further perfected as virtually all aspects of growth and development in the modern era has their basis in scientific knowledge and society needs citizens literate in science and technology at various levels to ensure overall progress. The most important role of science is to sustain the sense of awe and wonder in young people that come from exploring and understanding the natural and technological world. When science is well taught and student engagement is high, science can be the academic subject that keeps a child’s natural love of learning alive. Children learn science best and understand scientific ideas better if they are able to investigate and experiment. Hands-on science can also help children think critically and gain confidence in their own ability to solve problems.
Appreciation of science, like the appreciation of music, is likely to increase as one becomes more knowledgeable about how science is done. Normally students who do well in the school tend to be the ones that learn either by listening or by reading. So much of what happens in the regular classroom is focused only on these modes of learning. The tactile and kinesthetic learners are critically handicapped. To be effective, science education must be enjoyable. A bad teacher teaches the truth; a good teacher teaches how to find it. (Diesterweg, 1984) ‘Good’ teachers by thorough knowledge of their subject and general background kindle in their students the love for the subject keeping in view all the four types of learners. Once we believe that each child is capable of learning, a common approach used by a teacher shall not be relevant to all children. Learning should be made more child-centric. It should also be made multi-sensory with a variety of teaching methods and materials. This multi-sensory approach of teaching will allow the teacher to engage their students in learning activities that help both student and teacher experience an empowering rapport with scientific knowledge.

In science classrooms, the textbooks function as a source of knowledge whose meaning is mediated by both the developer of the instructional materials and teachers for students, who are expected to reconstruct or restate it. The manner in which authors present science influences the way it is received and interpreted. Textbooks play a major role in presenting content material, determining the nature of acceptable scientific explanations and testing the competency of students. Choices on methods and strategies will also affect the way textbooks engage their readers.

Methods and strategies chosen must make teaching realistic and effective and these are meant to supplement the teaching. The effectiveness of the use these tools depends upon the ingenuity and skill of the teacher who has to examine the necessity and suitability of these tools. Zero cost experiments, educational games and environmental observation are few locally available tools to any teacher to make her science class effective and interesting. Formal
experimentation – not demonstration, if commences from middle school level, will enable students tackle the basic concepts of science.

The main impediment of learning science by doing is 'not doing'. If science learning is to be made effective, the difficulties in learning science in the local context should be studied. These can be difficulties in teaching science as, the lack of resources, infrastructure, inadequate experience of the teacher and inadequate resources to teach the concept as provided in the textbook. The tools and techniques of teaching suggested as remedy should be readily available to the teacher and learner to experience science.

This study aimed basically at making science learning more meaningful by identifying the difficulties in learning science and providing instructional materials and methods as remedy and elevate the status of science from being an abstract discourse to lively science.

5.4 SIGNIFICANCE OF THE STUDY

In this study attempt has been made to identify the difficulties in learning science from its various perspectives such as availability of resources to learn, inadequate exercises, unclear picture in the textbook, necessity of real time examples to understand the problems, inadequate exercises to comprehend the problem, lack of simple activities to prove the phenomenon of study, necessity of group activities, lack of illustrations and inadequate problem solving and brain storming situations to comprehend the concept.

The study highlights the difficulties as perceived by the teacher and the student. The study will throw light on the extent of difficulty of the concept and also on the nature of difficulty as apparent by the teacher and the learner.

This study will enable researchers to study the background variables which could affect the nature a learner comprehends the science concepts. The study will also facilitate in
identifying the variables that makes the teacher sense a particular concept as difficult to be taught in the science classroom.

This study attempts to make learning of science effective by designing and developing instructional tools and techniques to help the teacher and the learner overcome the nature of difficulty. This study will also highlight the suitability of the material designed to the situational demand of teaching and learning.

This study will ensure that science learning could be made fun with the use of indigenous teaching learning material.

This study will show up the method of designing instructional tools and materials in line with the nature of difficulty perceived by the teacher and the learner.

This study will attempt to highlight the creative use of various instructional tools ranging from lecture methods accompanied by suitable audio visual material to activities where students are given chances to explore the concept by themselves. This study will help teachers the use of combination of teaching methodologies to bring in desired learning outcome in the students. It will also draw attention on the rarely used teaching methodologies in science such as brainstorming sessions and role play to make science learning more meaningful.

The remedial teaching learning material of this study will be a valuable resource material for any teacher to add to their existing knowledge on the concept. This study will help teachers utilize the material as a valuable resource to improve the comprehending of the concepts by the student. The same material will also be a rich source of reference for any learner to have methodical perception of the concept.

This study will endure evidence to the impact of the remedial teaching learning material on the nature of learning science. This study will also substantiate the impact of background variables on the effect of learning using the remedial teaching learning material.
5.5 SCOPE OF THE STUDY

Designing of instructional material needs careful analysis and planning. The diversified views of teachers on the nature of difficulty in making students comprehend the science concepts will help in the consideration of the views of teachers in the drafting of tutoring materials of science. The influence of background variables on the opinion of teachers will enrich awareness on the eligibility requirements of teachers to teach science.

Teachers are reflective practitioners: they accept that they can always find new and more inspiring ways of teaching a subject. This study will further expand their awareness of the creative use of indigenous tools and techniques to perfect science learning in students. This procedure of investigating the learning process and being a reflective practitioner will actually add stimulation and interest to one’s work and make teaching more fulfilling.

The view has been emerging today in teaching and learning situation is that it is not what is learnt but how it is learnt is important. The tools and techniques suggested will provide rich sources of information on making students learn science by doing science.

The tools and materials provided in this study will enable instructional material designers to use them as follow up, activity, home work, assignment and project materials to make learners become skilled at science.

The impact of varied instructional tools and techniques in teaching science will lead to more researches on analyzing the impact of exclusive tools in teaching specific science concepts.

5.6 TITLE OF THE STUDY

"IDENTIFICATION OF THE DIFFICULTIES IN LEARNING SCIENCE BY IX STANDARD STUDENTS AND PROVIDING REMEDIAL MEASURES".
5.7 OBJECTIVES OF THE STUDY

1. To identify the nature of difficulties in learning science by IX standard students.

2. To identify the extent and the nature of difficulty in teaching and learning the science concepts as perceived by teachers.

3. To develop remedial teaching learning materials to help teachers and students overcome the nature of difficulty identified.

4. To develop and validate an achievement test to analyze the effect of remedial teaching learning material on the achievement of students in learning the science concepts.

5. To find out the effectiveness of remedial teaching material by comparing the performance of students who used the intervention programme with those who have not used the intervention programme.

5.8 RESEARCH HYPOTHESES

The following research hypotheses were framed for this study:

1. The opinions of teachers on the extent and nature of difficulty in understanding the science concepts is varying significantly according to the background characteristics such as type of school, locality of school, qualification, experience, subject specialization and sex of teachers.

2. The ability of students in understanding the science concepts is varying significantly according to the background characteristics such as type of school, locality of school, medium of instruction, sex, achievement and community of students.

3. There is a significant variation between the entry and exit behaviour of teachers before and after attending the orientation program respectively.

4. There is a significant difference between the achievement test mean scores of experimental and control group students.
5.9 METHODOLOGY OF THE STUDY

5.9.1 SAMPLE

The sample for this study was drawn in four phases.

PHASE I - DIFFICULT CONCEPT IDENTIFICATION

33 Government School teachers and 69 Aided Schools teachers were selected as the sample to identify the difficult science concepts as perceived by them.

PHASE II - ADMINISTERING DIAGNOSTIC TEST

300 Government School Boys, 225 Government School Girls, 620 Aided School Boys and 360 Aided School Girls were selected as sample on whom the diagnostic test prepared was administered.

PHASE III - ORIENTATION PROGRAMME

The orientation programme aimed at orienting the teachers with the remedial teaching learning material developed by the investigator. 7 Government School teachers and 15 Aided School teachers were selected as the sample for this phase of the study.

PHASE V - IMPACT OF REMEDIAL TEACHING LEARNING MATERIAL

The experimental group refers to those schools, in which the teachers who attended the orientation programme taught science to students using the remedial teaching learning material. An equivalent group of students were selected as the sample for the control group from schools which did not use the RTLM kit. 90 boys and 50 Girls from government schools and 180 boys and 120 girls from aided schools were selected as the sample for the experimental group. 90 boys and 50 Girls from government schools and 160 boys and 140 girls from aided schools were selected as the sample for the control group.
5.9.2 TOOLS USED IN THE STUDY

Selection and designing of tools is the most important part of a research. The following tools were used in this study.

TOOL 1: DIFFICULT CONCEPT ANALYSIS OPINIONNAIRE

The difficult concept analysis opinionnaire was designed to gather a large data set of information on the extent of difficulty in teaching and learning the science concepts as perceived by teachers. It aimed at identifying the extent of difficulty as 'very difficult', 'moderately difficult' or easy. If very difficult or moderately difficult, the teachers' opinions were collected on the nature of difficulty in terms of both teaching and learning the science concepts. The responses were not limited to prefixed terms. Open statements on the nature of difficulty were collected. The opinions of the teachers were pooled on the 187 concepts given in the tool.

TOOL 2: DIFFICULT CONCEPTS DIAGNOSTIC TEST

The investigator developed test items for each difficult concept identified. The items used in the test were multiple choice items. The questions for the difficult concepts had distracting answers which helped the investigator diagnose the nature of difficulty. The knowledge, comprehension, application, analysis and synthesis domains were carefully included in the design of the test. This test consisted of 115 objective questions.

TOOL 3: REMEDIAL TEACHING LEARNING MATERIALS (RTLM)

Remedial instruction focused on specific areas depending on the nature of difficulty identified from the analysis of difficult concept analysis opinionnaire and the diagnostic test. The difficulties analyzed were from both teacher and learner perspectives. The tools were termed as remedial teaching learning material because these tools could be invariably used by the teacher.
to teach the concepts and by the learner to learn the concepts. One hundred and fifty three concepts were identified for the preparation of RTLM.

The teaching methodologies included in the RTLM kit were lectures, activity sessions, brainstorming sessions, dramatization and problem solving sessions. The tools included in the RTLM kit were flash cards, posters, picture books, analogies, flash card sets, worksheets improvised models and suggested indigenous materials. *These materials were developed in both English and Tamil versions to suit the medium of instruction.*

**TOOL 4: ENTRY EXIT BEHAVIOUR OPINIONNAIRE**

The multi-item scale with unidimensional single item measures constructed as difficult concept analysis opinionnaire was utilized again with modifications. The scaling dimensions were grouped as ‘difficult’ and ‘easy’. This was done to make the opinion of teachers more precise and clear. Only the 153 concepts which were identified as difficult from teachers’ perspective were included in the tool.

The orientation programme was conducted in two sessions. The entry behaviour of the teachers selected as sample for the orientation programme were already obtained during the participation of the same teachers as sample for the difficult concept analysis opinionnaire. The selected sample of teachers were then oriented in the use of RTLM. The orientation programme was conducted by subject experts so that the sessions could be made clearer and moreover the participants were also given opportunity to clarify their doubts to experts from the specific fields.

The exit behaviour opinionnaire was administered to the teachers to analyze their exit behaviour. Their opinion on whether the RTLM helped them overcome the nature of difficulty in teaching the science concepts as perceived by them was obtained.
TOOL 5: ACHIEVEMENT TEST

The diagnostic test constructed and validated was again utilized with modifications. The diagnostic test identified 63 concepts as difficult based on the performance of the students in the test. The nature of difficulty was analysed and the RTLM was designed to help students overcome the difficulty. The impact of RTLM on the achievement of students was studied on analyzing the performance of students on those concepts which were identified as difficult. The achievement test therefore included only 63 concepts which were already identified as difficult.

The teachers selected for the orientation programme was trained in using the RTLM. The schools in which these teachers work were chosen as the experimental group of the study. The control group included students who learnt the science concepts through the conventional method.

5.9.3 DESIGN OF THE STUDY

The study was conducted in four phases. The study is a multi-instrument approach with a combination of survey and experimental research.

PHASE 1: DIFFICULT CONCEPT ANALYSIS

The main objective was to identify the difficult concepts in science from teachers' perspective. The teachers perceived difficulty in teaching science because of various intervening variables such as lack of adequate infrastructure, lack of adequate information in the text book, different subject background of the teacher and influence of other background variables in teaching the concept and difficulty faced in learning science. The experience of the teacher made the teacher perceive certain other concepts as difficult by understanding the nature of the student, how they process information and the performance of the students in comprehending particular concepts.
The difficult concept analysis opinionnaire was administered to collect data on the opinion of teachers on the extent and the nature of difficulty of the science concepts. The tool measured quantitative and qualitative data. Quantitative data was measured in the form of the number of teachers choosing a particular concept as ‘difficult’, ‘moderate’ or ‘easy’. The data collected revealed the extent of difficulty. Qualitative data was assessed in the form of open-ended responses. If a concept is stated as difficult, the teachers were asked to write their opinion on why the concept was difficult. The data collected revealed the nature of difficulty.

PHASE 2: PREPARING AND ADMINISTERING DIAGNOSTIC TEST

The primary objective was to analyze the difficult concepts in science from learners’ perspective. The tool used was a ‘Diagnostic test’. The difficulty in comprehending the concept was analyzed in terms of the action verbs. For example:

The student might find difficulty in

- recalling concepts due to intervention of a previously learnt concept.
- identifying the units of a concept from an equation or a definition.
- solving problems.
- applying the concept learnt in practical situations

The data collected provided information on the nature of difficulty faced by the students in learning the science concepts.

PHASE 3A: PREPARATION OF REMEDIAL TEACHING LEARNING MATERIALS (RTLM)

The extent and nature of difficulty in teaching and learning the science concepts as perceived by teachers and the nature of difficulty faced by the students in learning the science concepts was analyzed. Remedial teaching learning material were designed and developed to
help the teacher and the learner overcome the nature of difficulty identified in teaching an
learning the difficult science concepts identified in the IX standard science text book.

PHASE 3B: ORIENTATION PROGRAMME

The teachers from selected schools were oriented in using the RTLM. A RTLM kit was
provided to all teachers who attended the orientation programme. The orientation programme
was conducted in two sessions to provide a wide content coverage, to have a follow up of the
impact of using RTLM in the class. This time gap in the conduction of the two sessions also
helped the investigator to take adequate time in the careful preparation of RTLM. This stage
also helped the investigator get the feedback of teachers on the impact of RTLM.

PHASE 4: IMPACT OF RTLM

In the evaluation phase, the impact of RTLM was studied. This phase had a development stage
of one academic year. The RTLM was provided for 153 science concepts and these concepts
were scattered in the whole of the science textbook of IX standard science. The regular
curriculum of IX standard was not disturbed and as and when the teacher had to teach the
difficult science concept, the teacher oriented in using the RTLM made use of the RTLM kit. At
the end of the academic year, the impact of RTLM on the achievement of students was studied
through a simple experimental design—"Two Group Post Test Only Experimental Design".
The experimental group consisted of students selected from the schools where the teachers used
RTLM to teach the science concepts. The control group of students was matched in the other
demographic variables such as nature of school, sex, locality of school and medium of
struction. The achievement test was conducted to both the groups to study the impact of
RTLM in the achievement of students.
5.10 STATISTICAL TECHNIQUES EMPLOYED IN THE STUDY

In this study, the investigator has applied the following statistical techniques to analyze and interpret the data collected.

1. Chi square test of hypothesis of equal probability
2. Chi square test of hypothesis of independence (difference)
3. Calculation of chi square for 2 x 2 tables
4. McNemar test
5. ‘t’ test for large uncorrelated samples.
6. One way ANOVA on hypothetical scores.
7. Post ANOVA test of difference by use of ‘t’.

5.11 FINDINGS OF THE STUDY

The findings of the present study are given below:

STAGE 1A: IDENTIFICATION OF DIFFICULT CONCEPTS

1. There is no significant deviation between the opinion of teachers on the nature of difficulty of the following concepts:
   b. Friction – Explanation.
   c. Newton’s Second Law of Motion
   d. Allotropic Forms of Sulphur
   e. Pollution due to Carbon dioxide and

It therefore reveals that the teachers equally feel these concepts as highly difficult, moderate and easy to be dealt with in a science class. These concepts need remedial material to help the teacher and the learner overcome the difficulties in teaching and learning the science concepts.
2. One hundred and eighty one concepts show a significant deviation between the opinions of teachers on the nature of the concept.

1. Thirty-six concepts had a significant deviation because of high frequency distribution in the column “easy”. These concepts do not require any remedial material.

a. One hundred and forty five concepts had a significant deviation because of high frequency distribution in the opinion columns “high” and “medium”. These concepts need remedial material.

3. Concepts numbered 55 and 165 reveals almost equal frequency distribution in ‘difficult’ and ‘easy’ and hence these concepts also need remedial teaching learning material.

4. Of the 187 concepts included in the tool, 153 concepts are identified as those which require remedial teaching learning material.

STAGE 1B: ANALYSIS OF IMPACT OF VARIABLES

OPINIONS OF AIDED AND GOVERNMENT SCHOOL TEACHERS ON THE NATURE OF THE CONCEPT

1. Thirty-one concepts are accepted as ‘easy’ by both aided and government school teachers.

2. One hundred and thirty four concepts are accepted as ‘difficult’ by both aided and government school teachers.

3. Aided school teachers feel the following concepts as more difficult than government school teachers:

   Concepts 8, 9, 16, 85, 97, 103, 126, 170, 172 and 185. (Refer concepts at: Table D.4.1A c Appendix D).

4. Government school teachers feel the following concepts as more difficult than aided school teachers:
Concepts 3, 6, 11, 12, 28, 30, 43, 121, 122, 123, 153 and 184. (Refer concepts at: Ta D.4.1A of Appendix D).

OPINIONS OF RURAL AND URBAN SCHOOL TEACHERS ON THE NATURE OF THE CONCEPT

1. Thirty-five concepts are accepted as ‘easy’ by both rural and urban school teachers.
2. One hundred and forty six concepts are accepted as ‘difficult’ by both rural and urban school teachers.
3. Rural school teachers feel the following concepts as more difficult than urban school teachers:
   Concepts 23, 31, 133 and 171 (Refer concepts at: Table D.4.1A of Appendix D).
4. Urban school teachers feel the following concepts as more difficult than rural school teachers:
   Concepts 116 and 125. (Refer concepts at: Table D.4.1A of Appendix D).

OPINIONS OF MALE AND FEMALE SCHOOL TEACHERS ON THE NATURE OF THE CONCEPT

1. Thirty-six concepts are accepted as ‘easy’ by both male and female school teachers.
2. One hundred and forty four concepts are accepted as ‘difficult’ by both male and female school teachers.
3. Female teachers felt the following concepts as more difficult than male teachers:
   Concepts 80, 84 and 180 (Refer concepts at: Table D.4.1A of Appendix D).
4. Male teachers felt the following concepts as more difficult than female teachers:
   Concepts 6, 8, 115 and 116. (Refer concepts at: Table D.4.1A of Appendix D).
OPINIONS OF POST GRADUATE AND GRADUATE SCHOOL TEACHERS ON THE NATURE OF THE CONCEPT

1. Thirty-six concepts are accepted as ‘easy’ by both graduate and post graduate school teachers.

2. One hundred and forty six concepts are accepted as ‘difficult’ by both graduate and post graduate school teachers.

3. Graduate teachers felt the concept 137 (Refer concepts at: Table D.4.1A of Appendix D). as more difficult than post graduate school teachers.

4. Post graduate school teachers felt the following concepts as more difficult than graduate school teachers:

   Concepts 7, 91, 96 and 107. (Refer concepts at: Table D.4.1A of Appendix D).

OPINIONS OF THE TEACHERS WITH THEIR BASIC DEGREES IN BOTANY, PHYSICS, CHEMISTRY AND ZOOLOGY ON THE NATURE OF SCIENCE CONCEPTS

1. Thirty-six science concepts are felt as ‘easy’ to teach and learn by teachers irrespective of basic degrees in Botany, Physics, Chemistry and Zoology.

2. One hundred and forty seven science concepts are felt as ‘difficult’ to teach and learn by teachers irrespective of basic degrees in Botany, Physics, Chemistry and Zoology.

3. Teachers with their basic degree in ‘Physics’, ‘Chemistry’ and ‘Zoology’ felt the concept “Screw Gauge: Zero, Positive and Negative Error” as more difficult than teachers with their basic degree in the subject ‘Botany’.

4. Teachers with their basic degree in ‘Botany’ felt the concept “Acceleration” as more difficult to teach than teachers with their basic degree in “Physics” who felt the concept as more difficult to teach ‘Chemistry’ teachers. These teachers felt the concept more difficult to teach than ‘Zoology’ teachers.
5. Teachers with their basic degree in 'Botany' felt the concept—"mole concept" and "structure of mitochondria" as more difficult to teach than teachers with their basic degree in "Chemistry" who felt the concept as more difficult to teach than 'Zoology' teachers. These teachers felt the concept more difficult to teach than 'Physics' teachers.

OPINIONS OF THE TEACHERS WITH VARIED RANGE OF TEACHING EXPERIENCE ON THE NATURE OF SCIENCE CONCEPTS

I. Thirty-six science concepts are felt as 'easy' to teach and learn by teachers irrespective of their varied range of teaching experiences.

2. One hundred and forty two science concepts are felt as 'difficult' to teach and learn by teachers irrespective of their varied range of teaching experiences.

3. One hundred and forty two science concepts are felt as 'difficult' to teach and learn by teachers irrespective of their varied range of teaching experiences.

4. Teachers with teaching experience of 13–24 years and 25–36 years felt the concept—"Manufacture of Glass" as more difficult to teach than teachers with teaching experience of 1–12 years.

5. Teachers with teaching experience of 1-12 years and 13-24 years felt the concepts—"Wave Motion: Definition" and "Carbon Cycle" as more difficult to teach than teachers with teaching experience of 25–36 years.

6. Teachers with teaching experience of 25–36 years felt the concepts—'Free Vibration', 'Structure of Chloroplast' and 'Hydra Vulgaris- External Structure' as more difficult to teach than teachers with teaching experience of 1-12 years. These teachers felt the concepts as more difficult to teach than teachers with teaching experience of 13-24 years.

7. Teachers with teaching experience of 1-12 years felt the concepts—'Earth as a magnet—Explanation', 'Tobacco Mosaic Virus' and 'Life Cycle of Plasmodium Vivax' as more difficult to teach than teachers with teaching experience of 13-24 years. These teachers
felt the concepts as more difficult to teach than teachers with teaching experience of 25–36 years.

**STAGE 1C: OPEN ENDED RESPONSE ANALYSIS**

The dimensions of the nature of difficulty identified were identified for all the 153 difficult concept. The nature of difficulties identified had a wide range. Few are listed:

1. The teachers had difficulty in providing individual exercises.
2. Student could not visualize the concept explained in a three-dimensional way when the teacher fails to show the real tool.
3. Teachers felt that the pictures given in book as not clear.
4. Teachers felt that enough practical exercises could not be given and
5. Lack of adequate tools of experiment to provide more exercises to the students.

**STAGE 2: DIAGNOSTIC TEST ANALYSIS**

**STAGE 2A: ANALYSIS OF DIFFICULT CONCEPTS**

1. *Almost equal distribution of wrong and correct responses:*
   
The responses of students were equally distributed in ‘correct’ and ‘wrong’ responses for 55 items in the diagnostic test. Hence the concepts which these items deal with are taken as ‘difficult’ items.

2. *Higher percentage of wrong responses:*
   
The percentage of students who have answered the items ‘wrong’ was high for 8 items in the diagnostic test. The concepts which these items deal with are taken as ‘difficult’ items.

3. *Higher percentage of correct responses:*
   
The percentage of students who have answered the items ‘correct’ was high for 52 items in the diagnostic test. The concepts which these items deal with are taken as ‘easy’ items.
4. Of the 115 concepts included in the tool, 63 concepts are identified as 'difficult' from student perspective. Hence these items will be considered to be included as those which require remedial teaching learning material

STAGE 2B: ANALYSIS OF IMPACT OF VARIABLES

1. The aided school students performed better than the government school students in the diagnostic test.
2. The performance of urban school students was better than the rural school students in the diagnostic test.
3. The boys performed better than the girls in the diagnostic test.
4. The English medium students performed better than the Tamil medium students in the diagnostic test.
5. The previous achievement of students in science subject had a significant influence on the performance of the students in the diagnostic test. The analysis of pairs of mean scores revealed the following:

   Better performance in the diagnostic test was seen between the following groups:
   a. The performance of very high achievers was better than the performance of high achievers.
   b. The performance of very high achievers was better than the performance of average achievers.
   c. The performance of very high achievers was better than the performance of low achievers.
   d. The performance of very high achievers was better than the performance of very low achievers.
e. The performance of high achievers was better than the performance of average achievers.

f. The performance of high achievers was better than the performance of low achievers.

g. The performance of high achievers was better than the performance of very low achievers.

h. The performance of average achievers was better than the performance of low achievers.

i. The performance of low achievers was better than the performance of very low achievers.

Almost equal performance in the diagnostic test was seen between the following groups:

a. Average achiever and low achievers.

6. The communities to which the student belonged had a significant influence on the performance of the students in the diagnostic test. The analysis of pairs of mean scores revealed the following:

Better performance in the diagnostic test was seen between the following groups:

a. The performance of forward community students was better than the performance of backward community students.

b. The performance of forward community students was better than the performance of most backward community students.

c. The performance of forward community students was better than the performance of scheduled caste and scheduled tribe community students.

d. The performance of forward community students was better than the performance of other non listed community students.

e. The performance of backward community students was better than the performance of most backward community students.
f. The performance of backward community students was better than the performance of other non listed community students.

g. The performance of scheduled caste and scheduled tribe community students was better than the performance of most backward community students.

h. The performance of most backward community students was better than the performance of other non listed community students.

i. The performance of scheduled caste and scheduled tribe community students was better than the performance of other non listed community students.

Almost equal performance in the diagnostic test was seen between the following groups: Backward community and scheduled caste / scheduled tribe community students.

STAGE 2C: ANALYSIS OF NATURE OF DIFFICULTY - IDENTIFIED FROM STUDENT RESPONSES

The nature of difficulty was studied on discussion with the subject experts. The results are given in table D.4.2C.1 and the interpretations of the results for every individual questions identified as difficulty are given in table D.4.2C.2 of Appendix D.

STAGE 3: ORIENTATION PROGRAMME- ANALYSIS OF ENTRY AND EXIT BEHAVIOUR OF TEACHERS

1. The teachers feel that for all 153 concepts identified as difficult, the remedial teaching learning material could help them overcome the difficulty in teaching and making students learn the science concepts.

2. The low value of ‘P’ obtained for all items (given in table D.4.3 of Appendix D) reveals that there is high significance in the difference obtained in the opinion of teachers. The teachers were highly satisfied with the use of RTLM in teaching science.
STAGE 4A: ANALYSIS OF IMPACT OF REMEDIAL TEACHING LEARNING MATERIAL

The experimental group students performed better than the control group students in the achievement test. This further reveals that the remedial teaching learning material utilized in the classroom was effective in helping students overcome the difficulty in learning the science concepts identified.

STAGE 4B: ANALYSIS OF IMPACT OF VARIABLES

1. The performance of experimental group students was better than the control group students in terms of background characteristics such as type of school, locality of school, medium of instruction, sex, achievement and community of students.

2. The aided school students performed better than the government school students in the achievement test. The intervention programme in the form of RTLM was well utilized by the aided school students.

3. The performance of rural school students was better than the urban school students in the achievement test. This finding was contradictory to the finding of the diagnostic test. This shows that the remedial material has significantly improved the performance of rural school students in comprehending the identified science concepts.

4. The girls performed equally well as the boys. This finding was contradictory to the performance of girls in the diagnostic test. The remedial material has improved the performance of girls better than it was earlier.

5. The Tamil medium students performed equally well as the English medium students. This finding was contradictory to the performance of Tamil medium students in the diagnostic test. The remedial material has improved the performance of Tamil medium students better than it was earlier.
6. The previous achievement of students in science has a significant influence on the performance of the students in the achievement test.

Better performance in the achievement test was seen between the following groups:

a. The performance of very high achievers was better than the performance of high, average, low and very low achievers.
b. The performance of high achievers was better than the performance of average and very low achievers.
c. The performance of average achievers was better than the performance of very low achievers.
d. The performance of low achievers was better than the performance of very low achievers.

Almost equal performance in the diagnostic test was seen between the following groups:

a. Average achiever and low achievers.
b. High and low achievers.

*The RTLM was proved to be effective in making low achievers comprehend the science concepts through its varied range of teaching and learning materials.*

7. The communities to which the student belonged had a significant influence on the performance of the students in the achievement test. The analysis of pairs of mean scores revealed the following:

Better performance in the achievement test was seen between the following groups:

a. The performance of forward, backward and most backward community students was better than the performance of scheduled caste and scheduled tribe community students and other non listed community students.
b. The performance of most backward community students was significantly greater than the performance of all other community students.
The RTLM has significantly improved the performance of this category of students whose performance was significantly lesser than forward and backward community students in the diagnostic test.

Almost equal performance in the achievement test is found between the forward community and backward community students. This finding also reveals that the RTLM could improve the performance of students from less privileged communities.

5.12 DISCUSSION

Krishnan (1981) observed that the curriculum of Tamilnadu was weak in dimension of methodical-instructional. Sundararajan (1988) also observed that the hierarchy of the objective related to the teacher gave more importance to knowledge. This study also revealed that teachers felt difficulty in making students comprehend definitions. The methodical instruction followed by teachers made them critically think of the methods of explaining the different allotropic forms of sulphur. They felt that the change in the structure of the allotropic forms should be made clearer through following some methodical procedures.

Krishnan (1981) also observed that the curricula did not give much importance to self study and practical work. This is revealed in this study where the teachers, out of the 187 concepts identified and chose 153 (81.82%) as difficult concepts which needed remedial instruction. The interest of the teachers in making science instruction more practical oriented in also revealed through this finding.

Krishnan’s study also revealed that the curriculum was more rigid to provide meaningful experiences outside the classroom. The concepts identified as difficult through this study also included concepts such as ‘graphical representations of motion’, ‘Newton’s laws of motions’, ‘expansion of solids’, ‘gas laws’, ‘sound waves’ and ‘laws of conservation, definite proportions and multiple proportions’, which needed more meaningful experiences in the classroom to make
it more life oriented. The first phase of the study also revealed that the investigator should provide these experiences with items, which are within the reach of the teacher and the learner.

Ashraf, Mohammed’s (1988) study revealed that the absence of funds had a direct and adverse impact on the smooth functioning of an innovation. This study reveals that innovative methodologies such as analogies, usage of improvised teaching aids, brain storming and problems solving sessions could be utilized and thereby help teachers proceed with effective science delivery with the minimal facilities available.

The study of Ashraf also revealed many other hurdles such as large number of students in a class, shortage of equipments and lack of properly trained staff in implementing methodologies. This study also goes in par with the above difficulties and revealed additional difficulties as lack of adequate equipments to provide individual exercises, unclear pictures, lack of adequate practical experiences, difficulty in differentiating related concepts, improper comprehending of concepts, lack of real time examples, lack of exercises to make students apply concepts and solve problems, lack of simple activities which could be done within the limits of classroom situations, lack of enough examples, lack of adequate exercises in helping students interpret situations, difficulty in comprehending the meaning of terms given in a definition, lack of enough exercises to help students apply the concepts learnt in science with real time situations, lack of clear three dimensional pictures to help students visualise the nature of certain concepts, lack of simple experiments to make students visualize the phenomenon, (For examples: linear expansion of solids and longitudinal motion of sound waves.), lack of adequate guidelines to help students develop or construct a simple model to explain the science concept, difficulty in comprehending the nature of certain science concepts, difficulty in identifying real time situations where the given science concept occurs, lack of adequate illustrations to explain students the difference between related concepts, inadequate suggestions on simple experiments.
to be performed in class with available materials and lack of activities to make students aware of
the real problems of misuse of science.

Unlike Ashraf's study where he found that the sex of the students and teachers was an
important factor in the success or failure of an innovative classroom practice, this study revealed
that irrespective of the sex of the teachers, for most of the concepts, there was no difference
between the opinion of the teachers on the extent of difficulty of the concept.

Sundararajan (1988) observed that generally teachers followed only the expository type
of teaching strategies in biology. The opinion of teachers on the nature of difficulty revealed
through this study also agrees with this finding and with the opinion that the schools did not
have essential teaching aids.

Gadkari (1982) observed that students developed wrong concept in the subject science.
This study also agrees this finding, which is revealed through the performance of students in the
diagnostic test. For concepts such as 'mole concept' and relating terms such as speed, velocity
and acceleration, the teachers felt that students developed wrong concept formation.

Leming, S James (1998) observed that the superficial coverage of content by the teachers
leaves less time for activities. This study also reveals that for most of the concepts the nature of
difficulty observed by the teacher is the lack of thoughtful activities to teach the concept.

The studies made by Nathan, Raventhra (1983), Darchingpui (1989), Joshi (1989),
Harlan, Donna Lynne (1986), Enzor, Sharon Lynn ball (1991) and Woodbury, Jacqueline
Margaret (1995) revealed the impact of variables in teaching and learning science.

Nathan observed that the medium of instruction influenced science achievement and
found better performance in English medium students. This study also revealed the same
through the performance of students in the diagnostic test.

Darchingpui observed that the sex of children did not have influence on the achievement
of students. However, this study revealed through the diagnostic test that boys showed bette
performance than girls did. In line with Joshi’s observation and that of Enzor this study also found that the teaching experience of teachers had a significant influence on the teaching of science. The opinion of teachers on the nature of the concept had wide variations based on the years of teaching experience.

Vardhini (1983), Dighal (1985), Prakash (1990) and Cartana I Pons, Joseph (1994) observed that visual projections in the form of charts and models provided concretized instruction and improved the performance of students.

This study also reveals that the teachers who participated in the orientation programme felt that the concretized instructional material in the form of flash cards, posters, models and analogies would help the learner overcome the difficulty in learning science. The better performance of the experimental group also reveals the positive impact of the RTLM prepared.

Prakash (1990) and Pittman Kim Marie (1997) observed analogies as an effective instructional strategy to teach science. This study made use of analogies to teach ‘Law of Definite Proportions’ and ‘Ultra Structure of a Plant and Animal Cell’. The analysis of exit behaviour of teachers who participated in the orientation programme revealed that these teachers felt this method as effective to help students overcome the difficulty in learning the concept.

The study used combination of methodologies and tools for most of the concepts and found the method to be effective through the analysis of exit opinion of teachers and the behaviour of the experimental group. This finding is also in accordance with the observation of Shista, Rama (1990) who observed that treatment of teaching concepts with blended strategies and different modes of teaching improved the achievement of students.

This study found brainstorming, problem solving and activity sessions as also effective instructional strategies to teach science. This finding is in accordance with the observation of Malik (1990), Sturdivant, Leon Harlie (1994), Wilson, Julie Luft (1994), Monaghan, Chery Ann (1995), Kao, Wen Ming (1995) and Pedell, Brian Jeffery (1996). Moreover Michalto
Micheal (1998) observed that productive thinking helps an individual to think of alternative approaches for a problem. Calvert, Renna Marcia Biggers (1996) used a similar approach ‘How can you know’ and observed that students developed pride and confidence in their work through this strategy and reported a positive impact on instruction.

Mohapatra (1989) observed that students made a great deal of conceptualization based on day-to-day happening in the environment and in home situations. The illustrations in brain storming and activity sessions of this study had real time examples and applications. The performance of the experimental group proved this strategy as effective.

The remedial teaching learning material significantly improved the performance of girl students and Tamil medium students whose performance was significantly lower in the diagnostic test. The performance of aided students was better than the performance of government school students in the experimental group. This revealed that the aided school students used the intervention programme in the form of remedial teaching learning material better than the government school students did in the experimental group. The findings of this study also revealed that the remedial teaching learning material improved the performance of students from less privileged communities.

5.13 EDUCATIONAL IMPLICATIONS AND RECOMMENDATIONS

The analysis of identification of difficult concepts revealed the nature of difficulty felt by teachers in teaching and making students learn the science concepts. This phase of the analysis revealed that the science concepts given in the textbooks needs more clear pictures and photographs, needs more suggestions on simple experiments to be performed inside the classroom, needs more illustrations of real-time applications, needs more situations to make students think, interpret and apply science concepts learnt to practical situations. Needs more
practical tips to help students construct simple models to explain science concepts and more elaborate explanations of science concepts.

The opinion of teachers on the extent and nature of difficulty revealed that the teachers were able to identify a wide range of difficulty so that proper remedial material is prepared to make science learning more effective. The performance of students in the diagnostic test revealed that students need more exercises to help them practice problems and differentiate terms related to a specific concept. They need more situational exercises to help them apply the concept to real life situations. These exercises are also needed to help students identify the underlying principle of the given science concept. They need practical tips to help them construct their own indigenous models to learn certain science concepts. They need illustrations to help them differentiate and comprehend related concepts. The students need training in knowing the etymological meaning of important scientific names and terms in their textbook to help them remember the concept well. They need three dimensional or photographic representations of concepts to comprehend them in a better way. These pictures and photographs can also lead to clear understanding of the underlying phenomenon of the concept.

The remedial teaching learning material developed and validated is an effective tool to teach the identified science concepts.

The flash cards and posters developed for certain concepts as screw gauge can help teachers overcome the difficulty of availability of inadequate number of instruments available to give individual exercises to students.

These flash cards can also help the teachers to introduce a lesson and set the tempo of what the students are going to learn in the class.

These flash cards and posters present clear pictures and photographs of the science concepts identified as difficult.
The brainstorming, problem-solving, and activity sessions suggested can be well utilized by any teacher and learner to practice exercises in solving problems in science concepts, interpret situations, apply concepts in real-life situations and identify the basic principle underlying the science concept.

The improvised models provided will help teachers and learners visualize the concepts in a better way.

The suggested teaching aids will help teachers and learners make use of the indigenous material available for effective science learning.

The remedial teaching learning material manual will be an effective guide material to inform the teacher the objectives of teaching the particular session, to notify the learner the learning objectives for the session, the procedures for doing the experiments, suggestions on activities, guidelines for problem-solving sessions, instructions on steps to follow to construct simple models to learn the given science concepts, motivating questions for brainstorming sessions and the method of concluding the sessions.

This material will serve a dual purpose of being a guide material for the teacher to teach science effectively and for the learner as a self-study reference material to overcome the nature of difficulty identified in learning the science concept.

The RTLM manual and the materials are in both the mediums, English and Tamil so that the teacher and the learner irrespective of the medium of instruction could use it.

5.14 RECOMMENDATIONS

Based on the above findings the investigator suggests the following recommendations in order to improve and modify the current educational practice:

1. The textbooks should contain more illustrations to help students apply the concepts learnt in real-life situations.
2. The pictures given in the textbooks should give a three dimensional representation of the concept introduced.

3. More clear photographic colour images of microscopic organisms could be provided.

4. Suggestions on group discussions, brain storming, problem solving and activity sessions could be provided.

5. Text books should provide hints on using indigenous teaching material to teach the given concept.

6. In a system where teacher of any basic discipline of science is recruited as science teacher, there could be intermittent orientation on the procedures of teaching a particular science concept. This would help the teacher of any discipline get oriented on the concept itself and on the ways of making the science learning effective through choosing the proper methods of instruction.

7. The textbooks should accompany teacher resource materials, posters, laboratory manuals, user manual of teaching aids and tools, workbooks, transparencies and test bank to make science learning meaningful and life oriented.

5.15 SUGGESTIONS FOR FURTHER STUDY

Based on the present study, it is suggested that similar studies could be undertaken for teaching other subjects in the curriculum at various levels.

1. As the study is pertained to the Science curriculum prescribed in Tamilnadu State Board Syllabus, similar studies could be attempted with the Science curriculum of Matric and CBSE curriculum.

2. Identification of difficult concepts and development of remedial material could be attempted in other subjects.
3. Electronic based remedial teaching learning material could be prepared and its impact in overcoming the difficulties in comprehending the science concepts could be made.

4. Comparative studies on the effectiveness of specific innovative instructional methodologies in teaching selected subjects could be made.

5.16 CONCLUSION

In the light of the research findings it is felt that the present study may contribute on the alleviation of difficulties in learning science. The findings of the study prove that the use of indigenous teaching learning situations leads to effective comprehending of science concepts. The impact of remedial teaching learning material on improving the performance of students indicates that science learning could be made interesting and effective through a variety of tools and techniques in the teaching learning situation. If science learning is made conceptual through proper designing and use of teaching learning situations, learning science becomes very effective. It is the right time that we realize this and gear up our efforts towards providing meaningful science learning experiences to our young generation through planned selection of tools and techniques of teaching.