Research is oriented towards the discovery of new knowledge. Webster’s International Dictionary proposes a very inclusive definition of research as, “a careful critical inquiry or examination in seeking facts or principles, diligent investigation in order to ascertain something”. Methodology is a science of orderliness. The dignity of any research can be realized by a proper methodology. Systematic planning in research is essential to save time, money and energy, a lot of failure and frustration in the path of progress.

Research may be classified into different categories depending upon its purpose. There are different types of research which demand different methods; require different tools for gathering data and different ways of analysis both statistical and non-statistical for arriving at a valid conclusion. Research Methodology involves the systematic procedures by which the researcher starts from the initial identification of the problem to its final conclusions. The role of methodology is to carry on the research work in a scientific way. The method of research provides the tools and techniques by which the research problem is solved. The methodology consists of procedures and techniques for conducting a study and analyzing the collected data as well. Research procedures are of little value unless they are used properly.

Research Methodology includes such general activities like identifying problems, review of literature, formulating hypothesis, procedure for testing hypothesis, measurement, data collection and analysis of data, interpreting results and drawing conclusions. Thus, research methodology consists of all general and specific activities of research (Sharma, 2008). It is the responsibility of every researcher to look into the methodological factors of any kind of research work very seriously and meticulously so as to find out an accurate result. In this study the investigator conducted a
research in finding out the effect of CAI and CL on the achievement of Chemical Bonding in Chemistry.

3.1 STATEMENT OF THE PROBLEM

The process of teaching and learning occurs in the Indian classrooms which are almost free from modern technology. There are many reasons why teachers do not use technology during their lecture. Firstly, most of the teachers do not know even how to operate a computer. Many teachers who know to use computer do not know how to incorporate technology into their teaching-learning process. A lot of teachers do not have enough time to use technology or any other teaching strategies while they handle their classes. This kind of lethargic attitude of teachers towards their way of teaching really affects their wards. Students of this age are very much aware of technology rather than their teachers. Teachers have to understand how they can manipulate technology for their teaching purpose. Technology, knowledge, information, and communication, as well as the impact of these components on teaching and learning lie in the hands of teachers. The teachers must have vision of new direction for today's technologies particularly, computer technology as indispensable tools for them. To use these technologies responsibly and humanely, they need to understand their potential, have opportunities to apply them, be supported in their explorations, and have time to experiment. Equally important, they need to acquire dispositions to recognize and acknowledge technology as more than a tool for teaching and learning.

Even pre-service teachers' perceptions of technology in their classrooms indicate that their perceptions were rather limited and reflected on four basic themes: technology as managerial support, technology as a motivational tool, technology as an unreliable or difficult requirement for teachers and technology as an unknown (Kraus et al., 1994). Such limited perceptions may not serve teachers well in developing technological competencies for some critical issues in educational and institutional contexts. Students are enthusiastic and flexible about new learning via computers. But in fact hardly a few schools have the technology for innovative learning. Only if,
teachers realize that technology opens the doors to new ways of teaching and learning, their wards will really enjoy its benefits. It is just another vehicle for learning. It opens up a world of opportunities in the classroom. Computers motivate children. It will be mandatory in the future that computer literacy must be one of the essential qualities for teachers at their entry point in schools.

A variety of teaching strategies have been advocated for teaching science in classrooms. They range from teacher-centred approach to more students-centered ones. Instructional methods differ in their ability to influence knowledge, skill and attitude. Teachers must be able to evaluate the strength and weakness of the methods they use in their classrooms. They have to analyze and choose an appropriate instructional tool while they teach in their classroom.

An appropriate educational technology in the hands of competent teacher can ensure better teaching and learning process. Moreover, in a fast developing world, where knowledge explosion is taking place in every sphere, it is unreasonable to expect especially science teaching, that mere spoken or written words alone can convey the volume of relevant information to attract the learning attention of the students who learn through different senses so that their inquisitiveness and understanding become better. Further, the concept taught will remain longer in the memory of the learner. According to Aladejana (2007), science teaching at various levels retains the old conservative approach with the teacher, in most cases, acting as the repertoire of knowledge and the students the dormant recipient. But teachers should not fail to know how they can so beautifully explain their subjects via Computer Assisted Instruction (CAI) and Co-operative Learning (CL). As these strategies are becoming an increasingly popular technique for education, teachers cannot simply brush aside these effective strategies; instead they have to make use of it in their classroom teaching. CAI and CL may be the effective way of providing instruction in Chemistry. There is tremendous excitement among educationists regarding the application of CAI in teaching English, whereas limited number of strategies is followed in teaching the abstract
concepts of Chemistry. CAI and CL strategies can change the theory of traditional methods of teaching.

In the last decade, a large number of researches were done on various subjects to find out the effect of various technologies. But for teaching chemical bonding which is one of the toughest areas in Chemistry, none of the investigators in the past took it up for their research. The investigator being a science teacher felt the need of paradigm shift from traditional method of teaching to innovative strategies. She wanted to do an experiment with the select strategies (CAI and CL) so as to find out their effect on the achievement of the first year higher secondary students in Chemical Bonding. Hence, this piece of research work is entitled “The Effect of Select Teaching Strategies on Achievement of Higher Secondary Students in Chemistry”.

3.2 Operational Definition of the Key Terms

The investigator adopted the following definition for the key terms used in the title of the study.

a) Effect

It refers to a change which is the result anticipated after the treatment administered to the subjects.

b) Teaching Strategies

They refer to the teaching techniques employed for making the students’ learning easy, interesting and effective.

c) Achievement
It refers to the learning outcome of the students after administering a proposed
treatment to them.

d) **Higher Secondary Students**

They refer to the students who study XI & XII immediately after their secondary
school education. The investigator has chosen only the XI Standard students for the study.

e) **Chemistry**

It refers to the branch of science that studies the composition, structure, properties and
change of matter. It is chiefly concerned with atoms and molecules and their interactions and
transformations.

f) **Computer Assisted Instruction**

It refers to an interactive instructional strategy whereby a computer is used to present
the instructional material and the instructor monitors the learning that takes place among the
students.

g) **Co-operative Learning**

It refers to an instructional technique in which students work in small groups
or as a team to solve a problem, complete a task or accomplish a common goal.

h) **Chemical Bonding**

It refers to the existence of a strong force of binding between two or many atoms
resulting in the formation of a stable compound with properties of its own.

### 3.3 OBJECTIVES OF THE STUDY
Every study must possess some objectives which must bring about measurable and observable outcomes in the research process.

The major objectives of the study are:

1. To develop a Computer Assisted Instruction (CAI) package on Chemical Bonding for the experimental group-I

2. To prepare and present the instructional material on Chemical Bonding for experimental group-II (CL)

3. To find out the significant difference, if any, in the pre-test scores of the control group and the experimental groups-I and II and also with regard to the level of intelligence

4. To find out the significant difference, if any, in the post-test scores of the control group and experimental groups-I and II and also with regard to the level of intelligence

5. To find out the significant difference, if any, between the pre-test and post-test scores of the control group and experimental groups-I and II

6. To find out the significant difference, if any, between the gain scores of the experimental groups-I and II

7. To find out the significant difference, if any, between the delayed post-test scores of the control group and experimental groups-I and II and also with regard to the level of intelligence

8. To find out the significant difference, if any, between the adjusted post-test scores of the control group and experimental groups-I and II and also with regard to the level of intelligence

3.4 HYPOTHESES FORMULATED

The hypothesis is a formal affirmative statement predicting a single research outcome, a tentative explanation of the relationship between two or more variables (Best & Kahn, 1995). The
hypothesis focuses the investigation on a definite target and determines what observations or measures are to be used. In the light of the objectives, the following null hypotheses were set up for the present study with reference to Pre-test and Post-test.

1. There is no significant difference between the pre-test scores of the control group and experimental groups-I & II.

2. There is no significant difference between the pre-test scores of the control group and the experimental groups-I & II with regard to the level of intelligence.

3. There is no significant difference between the post-test scores of the control group and the experimental groups-I & II.

4. There is no significant difference between the post-test scores of the control group and the Experimental groups-I & II with regard to the level of intelligence.

5. There is no significant difference between the pre and post-test scores of the control group and the experimental groups-I & II.

6. There is no significant difference between the gain scores of the control group and the experimental groups-I & II.

7. There is no significant difference between the gain scores of the experimental groups-I & II.

8. There is no significant difference between the delayed post-test scores of the control group and the experimental groups-I & II and also with regard to the level of intelligence.

9. There is no significant difference between the adjusted post-test scores of the control group and the experimental groups-I & II and also with regard to the level of intelligence.

10. There is no significant difference between the adjusted delayed post-test scores of the control group and the experimental groups-I & II.

3.5 VARIABLES UNDER THE STUDY
The measures used to assess the effect of the independent variables are known as dependent variables and the factors that the researcher controls or manipulates are called Independent variables (Shaughnessy and Zechmeister, 2006). In the present study, *Achievement is the dependent variable and CAI and CL strategies* are the independent variables.

### 3.6 DESIGN OF THE STUDY

Research design refers to the scheduling of the times at which treatments are administered to subjects and at which observations are made of the performance of the subjects. It is rather an important component of the research process of establishing cause and effect relationships. By combining careful research design with appropriate measurement, analysis and reasoning, the validity of the conclusions drawn from the research efforts can be strengthened (Vockell, 1983).

*The study has been designed in the following stages.*

**Stage- I: Grouping the sample into equivalent groups for control, CAI and CL**

At this stage, the sample representing the population is divided into three groups namely control group and experimental groups-I & II after conducting intelligence test to the population. The scores in the above tests proved the homogeneity of the groups.

**Stage-II: Administering treatment to both the groups (control and the experimental)**

At this stage, both the control and the experimental groups were given treatments. The control group was taught through conventional method in an ordinary way of teaching. The experimental groups-I & II were administered treatment through CAI and CL respectively.

**Stage- III: Conducting post-test and retention test for both the groups.**
At this phase, both the control and experimental groups underwent post-test as soon as the treatment period was over. The retention test was conducted for both the experimental groups ten days after the post-test was over.

**Stage- IV: The Results of the Treatment**

The effectiveness of the CAI & CL was found out by the results of the post-test and delayed post-test scores.

*The schematic representation of the research design is given in the table below:*

**Table 3.1**

**Schematic Representation of the Research Design**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nature of the Experiment</td>
<td>Pre-test – Post-test Equivalent Group Design</td>
</tr>
</tbody>
</table>
| 2      | Variables           | *Dependent variable*  
Achievement   | *Independent variable*  
CAI & CL     |
| 3      | Tools               | JerRe’s Achievement Test in Chemical Bonding    |
| 4      | Sample              | Control Group - 50  
Experimental Group -I–50 &  
Experimental Group –II–50  |
| 5      | Treatments          | Control Group – Conventional Method  
Experimental Group-I–CAI |
3.7 METHOD EMPLOYED IN THE STUDY

The investigator employed experimental method for the study. Experimental method can be used effectively to develop accurate descriptions of behaviour, especially when the methods are applied to practical research problems such as those involving the effectiveness of a behaviour modification programme (Shaughnessy & Zechmeister, 2006). This method is effective in establishing cause-and-effect relationships. The investigator employed the Pre-test - Post-test Equivalent Group Design (Best & Kahn, 2006) for the present study. The three groups of students studying in the same school were selected as the control group and the experimental groups-I & II. As the content is the same for both the experimental groups, the investigator has chosen only one control group for both the experiments.

3.8 ESTABLISHING HOMOGENEITY

Formulation of Groups

Three groups were formulated to conduct this study. They were equated on the basis of pre-test scores. Matching technique was used to equalize the groups. To find out the effectiveness of the methods of teaching on different ability groups: the students of the three groups were further split into high, low and average categories. The students who obtained 60 and above marks were put
in the category of high achievers, 41 to 59 were put in the category of average and less than 40 were categorized as low achievers.

To establish the homogeneity of the three groups (one control group and two experimental groups) General Intelligence Test for Higher Secondary Students (GITHSS) standardized by Roma Pal and Rama Tiwari, (1987) was administered after being revalidated and the scores were analysed statistically. It is presented in the following table:

**Table 3.2**

**Significance of Difference between the Intelligence Test Scores of the Control and Experimental Groups of CAI and CL**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI</td>
<td>57.36</td>
<td>14.52</td>
<td>50</td>
<td>0.594</td>
<td>0.554</td>
</tr>
<tr>
<td>Control</td>
<td>59.06</td>
<td>14.11</td>
<td>50</td>
<td>0.594</td>
<td>0.554</td>
</tr>
<tr>
<td>Co-operative Learning</td>
<td>57.72</td>
<td>13.93</td>
<td>50</td>
<td>0.478</td>
<td>0.634</td>
</tr>
<tr>
<td>Control</td>
<td>59.06</td>
<td>14.11</td>
<td>50</td>
<td>0.478</td>
<td>0.634</td>
</tr>
</tbody>
</table>

In the above table, since p value is greater than 0.05, it can be concluded that there is no significant difference between the intelligence test scores of the control and experimental groups.

Further, to verify whether the three groups were homogeneous with regard to the level of intelligence, the intelligence scores of the three groups were categorized as low, average and high. Then the data were analysed to find out the significance of difference among the three groups and the analysis is shown in the following tables:

**Table 3.3**

**Significance of Difference between the Control Group and Experimental Group-I (CAI) with regard to the Level of Intelligence**
The above table shows that the p values is greater than 0.05 in all the three levels of intelligence such as low (0.620), average (0.306) and high (0.940). Hence, it is concluded that there is no significant difference between the control group and experimental group-I with regard to the level of intelligence at the time of establishing homogeneity.

### Table 3.4

**Significance of Difference between the Control Group and Experimental Group-II (CL) with regard to the Level of Intelligence**
The above table shows that the p values is greater than 0.05 in all the three levels of intelligence such as low (0.259), average (0.329) and high (0.884). Hence, it is concluded that there is no significant difference between the control group and experimental group-II with regard to the level of intelligence at the time of establishing homogeneity.

3.9 SAMPLE

A sample is a smaller group that represents the characteristics of the larger group or population. The performance of a sample is used to make an inference about the performance of the larger group. A sample comprises the individuals selected from the population about which the investigator seeks information.

The investigator selected students from Mount St. Joseph Higher Secondary School in Thiruvannamalai District, Tamil Nadu to serve as both control group and experimental groups-I & II. On the whole, there were 150 students, 50 each in control and experimental groups-I & II. The students were identified after conducting the intelligence test.

3.10 RESEARCH TOOLS

A tool is a data gathering device or procedure used for research investigation (Best and Kahn, 2005). Tools are used to collect relevant information of a research problem. They can be used for gathering both quantitative as well as qualitative data. Different kinds of tools whether self-made ones or standardized ones can be used for measuring the variables involved in the study. A research tool should have the characteristics such as validity and reliability.

The investigator used two tools for the experimentation of her study. They are:

i) General Intelligence Test for Higher Secondary Students (GITHSS)

ii) JerRe’s Achievement Test in Chemical Bonding (JATCB)
3.10.1 General Intelligence Test for Higher Secondary Students (GITHSS)

This was a standardized tool entitled ‘General Intelligence Test for Higher Secondary Students (GITHSS)’ (Appendix-1a) and it was used to establish the homogeneity of both the control and experimental groups. This is a test of intelligence for higher secondary students and it contains 70 items. The items were constructed with validity and reliability by the tool maker. All the questions are asked in simple language. In each case, alternative answers are given, and the students are directed to choose right number against the right answer. Each right answer carries one mark. The scoring key is given in Appendix-1b. The unanswered questions are also to be treated as wrong answers. The validated tool was administered to the sample for establishing the homogeneity of the group. The students who got 60 and above marks were put in the category of high intelligence, 41 to 59 were put in the category of average and less than 40 were considered as low intelligence. Thus, the control and experimental groups-I and II were formed.

3.10.2 JerRe’s Achievement Test in Chemical Bonding (JATCB)

The objective type questions of JerRe’s Achievement Test in Chemical Bonding (JATCB) were framed and given to four experts for content validity. The pilot study was conducted for the same. JATCB was administered to the students and the data were collected for item validation. As per the suggestions of the four experts, a few questions were modified. The description of JATCB is given in the following sections:

The preliminary draft of JATCB consisted of 125 questions. All the questions were of objective type which is given in Appendix-2(a). The topics covered for JATCB under chemical bonding were Classification of Molecules, types of Kossel Lewis Approach, Lewis Dot Structure, Lattice Energy, Fajan’s Rule, Born Haber Cycle, Polarization, Hybridization, Resonance VSEPR Theory and Dative Bonding.

3.10.3 Validation of JATCB
Validity is defined as the extent to which a test measures what it is intended to measure. It is used to determine whether the inferences about test scores are accurate (Santrock, 2006). A test is proper valid when it measures exactly what it aims to measure (Singh, 2007). Validity is a requirement for both quantitative and qualitative data. Validity should be seen as a matter of degree rather than as an absolute state. Hence, one strives to minimize invalidity and maximize validity (Cohen et al., 2000). After the preparation of JATCB, it was validated using content validity and item analysis in the following way.

### 3.10.4 Content Validity

Content validity refers to the degree to which the tool actually measures or is specifically related to the traits for which it was designed. The criterion of content validity is often judged by a panel of experts in the field who judge its adequacy (Best & Kahn, 2001). For establishing the content validity of JATCB, it was given to four experts for the purpose of validation. The tool was validated by the experts who had sound knowledge in the same field and had more than 20 years of experience in teaching at Higher Secondary School level. On the basis of their suggestions, corrections, deletions and modifications were carried out in the tool for reconstructing certain questions. The major attempts were: i) refinement of a few questions and reconstruction of certain structures in the question pattern for a better understanding, ii) alteration of some questions iii) elimination of some questions which confuse the respondents and iv) modification of certain questions which were difficult to grasp as far as Hybridization is concerned.

To improve further, the preliminary draft of JATCB was given to the parallel target group of twenty students of a school to know how they respond to the questions. This helped the investigator again to modify a few questions in the preliminary draft of JATCB. Thus, the content validity of the tool has been established.
3.10.5 Item Analysis of JATCB

For establishing the item validity of JATCB, the investigator chose two semi-urban Higher Secondary Schools and from them, she selected 100 students who were studying Chemistry in XI standard. She administered JATCB to them and evaluated their answer sheets.

Item analysis was done for JATCB in the following two Higher Secondary Schools in Thiruvannamalai District:

Table 3.5
The Schools Selected for Item Analysis

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the Schools</th>
<th>No. of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>St. Mary’s Higher Secondary Schools, Vettavalam</td>
<td>60</td>
</tr>
<tr>
<td>2.</td>
<td>Immaculate Heart Higher Secondary School, Kariyandal</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

3.10.6 Validation of the Items of JATCB

The procedure for validating the items of JATCB is as given below:

i. A score of 1 for the right response and a score of 0 for the wrong response were awarded.

ii. The sum of the scores obtained by all the respondents was calculated for each individual.

iii. The scores of the respondents were arranged in the descending order.

iv. The top twenty eight scores and the bottom twenty eight scores of the respondents were taken into account.

v. The difficulty index and discriminative index were then calculated.
vi. The items having difficulty index between 40 and 80 and discriminative index greater than 0.2 (Stanley, 1978) were selected and the remaining items were dropped out. The difficulty index and discriminative index of each of the items are shown in Appendix 2b.

The investigator could select 100 items out of 125. Thus the final draft of the tool consisted of 100 items (Appendix 2d) on the whole out of 125 (Appendix 2a). The scoring key is given in Appendix (2e). Thus, the validity of the tool was established.

3.10.7 Reliability of JATCB

Reliability is based on the notion that there is some sense of uniformity in what is being measured and that methods need to consistently capture what is being explored. It is thus the extent to which a measure, procedure or instrument provides the same result on repeated trials (Leary, 2005). If a measurement device or procedure consistently assigns the same score to individuals or objects with equal values, the instrument is considered reliable. Reliability involves the consistency, or reproducibility, of test scores i.e., the degree to which one can expect relatively constant deviation scores of individuals across testing situations on the same, or parallel, testing instruments (Zikmund, 2003).

The reliability of JATCB had been established by Split-half Method. In the split half method, the test is divided into two equivalent halves by considering all the odd numbered items as a set and the even numbered items as a separate set. The correlation for these half-tests was found to be 0.6794.

From the self-correlation of the half-test, the reliability coefficient of the whole test (r’) is given by the Spearman-Brown Prophecy Formula (Garrett, 2005). The value of r’ was found to be 0.8091 which indicates that the tool is highly reliable (Best & Kahn, 2006).

3.10.8 Establishing Reliability
Reliability means consistency of scores obtained by same individual when re-examined with the test on different sets of equivalent items or under other variable examining conditions (Best & Kahn, 2006). Reliability is the proportion of variance attributable to the true score of the latent variable. Assessing scale reliability is crucial to maximizing power in one’s study. Simply put, unreliable scales decrease the statistical power of an instrument. An increase in statistical effect size is also observed with an increase in instrument reliability and subsequent power gained. Additionally, reliable instruments introduce less error into the statistical measurement and analysis (Devellis, 1991).

The items in the tool were divided into two equivalent halves and two set of scores were correlated. By this split-half method correlation was calculated. Then the reliability of the tool was established by the Spearman Brown Prophecy formula,

\[ r_1 = \frac{2r}{1+r} \]

where,

- \( r \) – Correlation Co-efficient
- \( r_1 \) – Reliability of co-efficient of the tool.

The reliability of co-efficient using the above formula was found to be 0.66 for JATCB. Thus, the reliability of the tool was established. The Scoring Procedure of JATCB is given in Appendix 2c.

### 3.11 DEVELOPING THE PACKAGE FOR CAI

The investigator conducted a pilot study among the XI standard students about the difficulty level of their subjects. The result of this study showed that most of the students felt difficulty in learning Chemical Bonding. So to make it easy in teaching-learning process, the CAI package was developed for “Chemical bonding”.

The package for teaching the lesson Chemical Bonding was developed to teach the content through CAI. It is a combination of various forms such as video, audio, images, animation and text. The package was developed in such a way that any student can play and learn the content, for which minimum operating knowledge of a computer is enough.

3.11.1 Formulation of Objectives

First of all, the objectives for the lesson Chemical Bonding were framed. They were given to four experts, two experienced professors of education and two professors of Chemistry. According to their opinion and viewpoints, general and specific objectives were fixed. The target of these objectives was reached to the students through CAI and CL.

3.11.2 Construction of Content

On the basis of the objectives, content was selected for the lesson. Equal importance is given to all the units concerned. The distribution of content is interlinked with each other. Similarly every unit is dependent on the other unit. The content in each unit is allocated on the basis of three levels namely easy, average and difficult.

3.11.3 Design of Computer Assisted Instruction Strategy

The content of each unit is used for designing the packages. It was administered only to the experimental group-I. The same objectives and content for Chemical Bonding were taken into account for the control group. The content of Chemical Bonding taught to the control and experimental groups is given in Appendix 3.

3.11.4 Validation of Content

The selected content for each unit was given to four experts belonging to the field of Technology and Chemistry for validation. After a thorough scrutiny by the experts, the content was
undergone a diminutive change. A few items such as *Calculation of Lattice Energy*, *Resonance* and *Polarization* were modified as they were beyond the level of the students. The length of the content was minimized. Thus, content validation was established for the package preparation.

### 3.11.5 Developing the Package

After the content validation, the CAI package on Chemical Bonding (CAIPCB) consisting of 12 units was prepared. Each single unit consists of sub-units. There are two to four video clips. The content of each unit, whether it is long or short, is accommodated according to the time consumption of 45 minutes to one hour. All the contents in the units were fused together in the form of text, video, sound and animation. This CAI package was given to four experts - one was from the department of technology; the second one was from the software industry; the third one was from the department of Physical Science and the fourth one was from the Department of Chemistry. As per their suggestions, various modifications, deletions and inclusions were done in the CAIPCB. Modifications were done in the editing of audio and video clips, deletion of blaring sound and so on. Again this module, after eliminating the errors was shown to the expert for the final approval. Then the package was taken to an individual, group and to the field tryouts to enhance the quality of CAIPCB. The tryouts were conducted in **two** schools.

**Table 3.6**

**Schools Selected for Tryouts**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the school</th>
<th>Tryout</th>
<th>No. of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Danish Mission Hr. Sec. School</td>
<td>Individual</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Danish Mission Hr. Sec. School</td>
<td>Group</td>
<td>5</td>
</tr>
</tbody>
</table>
Individual Tryout:

At first, the CAI package was taken to two individuals who were average students. They performed well in Different Types of Chemical Bonding, Theory of Born-Haber Cycle and Octet Rule. They experienced difficulties in Lewis Dot Formula, Resonance, Hybridization, Lattice Energy, Geometry of Molecules, Polarization and VSEPR Theory. The problems were rectified after consulting the experts.

As the Co-operative Learning Strategy involves small groups individual tryout is not applicable.

Group Tryout:

Secondly, the CAI package and CL content were taken to a group of five students. It was a heterogeneous group, consisting of bright, average and below average students and they were selected on the basis of their academic performance. The bright students could do well in all the contents except the Hybridization and Resonance. They could not give immediate response to a few questions. The average and the low performing students suffered a little in Calculation of Lattice Energy and Lewis Dot Formula. They were replaced by easy ones. The problems faced by the students were taken to the experts and according to their suggestions a few questions in the content were modified; some of the structures which were difficult to understand were replaced with ordinary ones. Thus, the CAIPCB and the CL content underwent for a slight modification.

Field Tryout:

Thirdly, the CAI package and CL content were taken to the field of a regular classroom. It aroused the curiosity of most of the students. Everyone participated with enthusiasm. Only the average and low achievers could not produce the expected outcome in almost all the
contents. The matters which were found complicated were put right in the CAIPCB and in CL content thereby it was given a final shape. Thus the CAIPCB and the CL content were established for its ready use.

3.12 TREATMENT USING COMPUTER ASSISTED INSTRUCTION

The CAI package was administered to the experimental group-I by the investigator whereas, the same content was taught to the control group through the conventional method in an ordinary way of teaching by the class teacher as per the instruction received from the investigator. The treatments were given to both the groups for a period of 15 days, 2 hours a day.

3.12.1 Procedure of the Treatment under CAI

In this study, the Pre-test - post-test Equivalent Group Design was followed. To analyse the effect of CAI on the achievement of chemical bonding, the investigator selected control and experimental groups on the basis of their intelligence. The control and experimental groups were given Traditional Method and CAI respectively. Pre-test was administered to both the groups and confirmed the equivalence of them. The investigator selected these two groups from a school located in Thiruvannamalai district after getting the special permission from the management for administrating the experiment for two hours a day. The chairman after a discussion granted permission to take one hour in the forenoon session and one hour in the afternoon session. The experimental group was taught by the investigator for a period of 15 days.

The achievement scores of the sample groups were obtained for all the tests namely, pre-test, post-test and retention test. The retention test was conducted after 10 days from the post-test.

3.13 Design of Co-operative Learning Strategy

The content of each unit is divided into sub-units. It was administered only to the experimental group-II. The same objectives and content of Chemical Bonding used for CAI were taken into account for this group also.

The content of Chemical Bonding for the experimental group-II is given in Appendix -4.
Co-operative Learning is a teaching strategy in which small groups of learners each with different levels of ability, use a variety of learning activities to work together as a team to solve a problem, complete a task or accomplish a common goal. In this strategy, the students listen, argue, discuss, explain and teach in their efforts to help each other and master the academic content presented by the instructor. Each member of a team is responsible not only for learning what is taught but also for helping team-mates to learn and thus creating an atmosphere of achievement. There are different methods in Co-operative Learning Strategy. Here, the investigator used Jigsaw Technique of Co-operative Learning and prepared the instructional material for the lesson Chemical Bonding.

The following steps were employed in the Jigsaw technique:

**Step-1: Introduction**

The lesson was presented by the investigator with an introduction of about 15 minutes.

**Step-II: Focused Exploration**

It included the following steps:

a) **Formation of groups:**

The teacher divided the Experimental group-II into 10 groups. Each group consisted of 5 members called ‘Base Groups’ or ‘Home Groups’.

b) **Task Assigned:**

The teacher assigned individual work based on the lesson to each member of each base group.

c) **Working in the Group:**

From the base groups those who got the same topics again formed another groups known as ‘Expert Groups’. In the expert groups they learnt and mastered the area assigned
to them with the help of the investigator getting their doubts clarified. While students were working in groups the investigator went around and observed each group and was a facilitator and helped them to attain the mastery level.

**Step-III: Reporting and Reshaping**

The students returned to their original groups and instructed to their team-mates what they learnt in their expert groups.

**Step-IV: Integration and Evaluation**

The groups connected the various pieces of information generated by the individual members and integrated into the whole. To test whether the students learnt the material well or not, the investigator asked review questions and elicited answers from the base groups.

**The instructions given to all group members are:**

i) Each student in a group of five should learn and solve the problems assigned to them and check with his/her partners. If anyone is not able to answer a question, then it is the responsibility of the team-mates to answer.

ii) If there was disagreement among team members, they have to present their arguments to solve their problems; they should ask the teacher for help.

iii) Students should finish the task only after each member of the group finish her task.

iv) If there is any doubt, they have to clarify with the team-mates before asking the teacher.

v) They have to encourage and praise their team-mates.

vi) The expert students should patiently explain each concept to weaker students and check whether their team-mates follow the explanation and encourage them to reach the mastery level.

By following the above steps the investigator prepared 12 units of instructional materials on Chemical Bonding in Chemistry. One of the model instructional materials is given in
Appendix-5 and the diagram depicting the technique of Jigsaw learning is given in the following figure.

**Diagrammatic Representation of Jigsaw Technique under Co-operative Learning Strategy**

The five Base groups are represented as A, B, C, D, E.

Where $A_1$ denotes the first student in Group A

$A_2$ denotes the second student in Group A

$A_3$ denotes the third student in Group A
A_4 denotes the fourth student in Group A
A_5 denotes the fifth student in Group A

Similarly,

B_1 to B_5 denotes the students in Group B
C_1 to C_5 denotes the students in Group C
D_1 to D_5 denotes the students in Group D
E_1 to E_5 denotes the students in Group E

Each student in the Base Groups is given a small segment of the unit and those who got the same topic go to the Expert groups, discuss and learn thoroughly. Then they return back to the original Base groups and teach their team-mates till they get the full knowledge of the assigned topic. Thus, they gain mastery over the unit Chemical Bonding.

3.14 THREATS TO EXPERIMENTAL VALIDITY

The sufficiency of the experimental design is judged by the degree to which the threats to experimental validity is removed or reduced. The experimental validity faces two kinds of threats, namely threats to internal validity and external validity.

3.14.1 Threats to Internal Validity

Internal validity is concerned with the extent to which the experiment is genuinely effective that is the extent to which the manipulations in the independent variable bring about changes in the dependent variable. It is concerned with the true variance in the dependent variable that has been brought about by the induced variations (treatment) in the independent variable. Internal threats are experimental procedures, treatments or experiences of the participants that can threaten the researcher’s ability to draw correct inferences from the data about the population in an experiment.
Experimental researchers need to identify potential threats to the internal validity of their experiments and design them so that these are not likely to arise or are minimized. Internal validity may be affected by a number of factors. The investigator found the possible threats to internal validity and made attempts to minimize them.

a) Maturation

Maturation implies the changes that the subjects involved in an experiment may undergo during the experiment. These changes may influence the dependent variable and this influence may be confounded with the changes (variance) due to the treatment. Often the change during an intervention may be due to factors associated with passage of time rather than to the intervention itself (Fraenkel & Wallen, 2006).

As the subjects selected were Higher Secondary students of similar intelligence group and the period of treatment was only 15 days, there was no scope for maturation. Thus this threat was nullified.

b) History

Some unexpected happenings that may occur during the time of experiment and may adversely or even at times advantageously affect the dependent variable. A true experiment requires that participants in the experimental groups and in the control group be treated the same i.e. they have the same history of experiences except for the treatment (Shaughnessy & Zechmeister, 2006).

In this study, no unexpected events for the experimental groups-I & II occurred during the experimental period of 15 days and thus this threat was eliminated by the investigator.

c) Testing

As subjects get some experience in taking test before the treatment this experience will help them do a little more better in the post-test than they would if they had not taken the pre-test.
Thus, pre-test effects may work against the internal validity of an experiment. An attempt to assess the effect of some intervention would be problematic if the assessment is simply the same students’ score on a pre-test and a post-test (Shaughnessy & Zechmeister, 2006).

The investigator in this study, conducted pre-test, post-test and retention test for both the control group and experimental groups-I & II during the period of experimentation. Thus, this threat was overcome.

d) Unstable Instrumentation

Unreliable instruments or techniques used to describe and measure aspects of behaviour are threats to the validity of an experiment (Best & Khan, 1995). At times the researchers may also make errors in measurements owing to lack of training in accurately handling the instruments. Unless controlled, the changes in instrumentation can threaten internal validity by providing alternate explanations for differences in behaviour between one observation period and another (Shaughnessy & Zechmeister, 2006).

In this study to measure the variables, the researcher used the tools, after proper standardization only. Thus, this threat was overcome.

e) Selection Bias

Samples should be representative of the populations. If the researcher does not make the control and experimental groups’ equivalent before the commencement of treatment, the sample she selects for the experiment is biased and the biased sample will not give correct result. From the outset of a study, differences exist between the kinds of individuals in one group of an experiment and those of another; there is a confounding due to selection (Shaughnessy & Zechmeister, 2006).

In the present study, there was no significant difference between the control group and experimental groups-I & II with regard to the scores of intelligence test and pre-test. Thus, this threat was minimized.
f) Location

The particular location in which data are collected or in which an intervention is carried out may create alternate explanations for results. This is called location threat. The location in which tests, interviews or other instruments are administered may affect responses (Fraenkel & Wallen, 2006).

The investigator in the present study did not choose any specific location for conducting the experiment. The treatment was administered within their classrooms. Hence, this threat was eliminated.

g) Implementation

The treatment or method in any experimental study must be administered by someone - the researcher, the teachers involved in the study, a counsellor or any other person. This fact raises the possibility that the experimental groups may be treated in ways that are unintended and not necessarily part of the method, yet which give them an advantage of some sort or another. This is known as an implementation threat (Fraenkel & Wallen 2006).

The investigator administered the same tools to the respondents of both the control group and the experimental groups-I & II. Thus, this threat was minimized.

h) Experimental Mortality

Mortality is the loss of subjects during the experimental period. When mortality occurs in one or the other groups the randomness or equality of groups suffers and the final results may not depict exactly the effect of the independent variable. Shaughnessy, & Zechmeister (2006) say that participants who are left in the experimental groups will differ from those dropped out if for no other reason than that they were able to do the task.

No loss occurred during the period of the experimentation. Hence, this threat was eliminated.
3.14.2 Threats to External Validity

True experiments may be weakened by threats to external validity. External validity arises when experimenters draw incorrect inferences from the sample data to other settings and past or future situations. The investigator has briefly stated the possible threats to external validity and how they were minimized.

a) Interaction of Selection and Treatment

It is because of the narrow characteristics of the settings of participants in an experiment, a researcher cannot generalize individuals who do not have the characteristics of the participants.

The selection of both the control and experimental groups was done by conducting the same intelligence test. Furthermore, the treatment for them lasted for the same days and the gap between the post-test and the delayed post-tests was the same for the groups. Hence, this threat was minimized.

b) Interaction of setting and treatment

It is because of the characteristics of the settings of participants in an experiment, a researcher cannot generalize individuals in other settings.

Using technological gadgets is very common in educational institutions. So the students selected to the experimental groups would not feel any artificiality and so there was no such threat.

c) Interaction of History and Treatment

The result of this particular experiment is time bound and so the investigator is not able to generalize the results to past or future situations.
The treatment to the experimental groups lasted for only 15 days. Thus, this threat was minimized.

3.15 DELIMITATIONS OF THE STUDY

Delimitations are the boundaries of the study. The conclusions of the study are not to be extended beyond the population studied (Best & Kahn, 2005).

The delimitations of this study are:

i. The investigator got hardly 15 days to conduct her experimental study.

ii. She taught only the lesson Chemical Bonding, not more than that. She could get two hours daily – one hour in the forenoon session and one hour in the afternoon session for CAI and CL respectively.

iii. The investigator did this experimental study only to three sample groups consisting of 50 students each.

iv. The control group was taught by the subject teacher whereas the experimental groups-I & II were treated by the investigator.

v. This study was conducted only in a school located at the semi-urban area. The investigator selected this particular school because it was the only school in which there were 150 students learning Chemistry.

3.16 STATISTICAL TECHNIQUES EMPLOYED

Descriptive Analysis (Mean, Percentage and Standard Deviation), Inferential Analysis (t test) and ANCOVA are the statistical techniques used for analyzing the data.

i) Levels

High level refers to the scores equal to or greater than (Mean + 1SD)

Low level refers to the scores equal to or less than (Mean + 1SD)

The in-between scores are at the average level.
ii) *t* test for independent groups is given by the formula

\[
t = \frac{X_1 - X_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}
\]

where,

- \(X_1\) – Mean for the control group
- \(X_2\) – Mean for the experimental group
- \(S_1\) – Standard Deviation for the control group
- \(S_2\) – Standard Deviation for the experimental group
- \(N_1\) – Size of the control group
- \(N_2\) – Size of the experimental group

iii) *t* test for dependent groups

The *t* test for dependent groups is given by the formula

\[
t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2} - 2r \left( \frac{S_2}{\sqrt{N_1}} + \frac{S_2}{\sqrt{N_2}} \right)}}
\]

where,

- \(\overline{X}_1\) – Mean of the first sample
- \(\overline{X}_2\) – Mean of the second sample
- \(S_1\) – Standard Deviation of the first sample
- \(S_2\) – Standard Deviation of the second sample
- \(N_1\) – Total number of first sample
- \(N_2\) – Total number of second sample
- \(r\) – Correlation of the first sample and the second sample.

iii) ANCOVA – Analysis of Covariance for the Control and Experimental Groups
After testing the data for the assumptions described above, one may proceed further with the analysis of co-variance to test the significance of the difference between the means of the criterion test scores of the experimental and control groups. The computational steps are given as under:

1. The first adjustment, based on the sums of squares and products of deviations from the total means

   \[ E_i = \left( \sum Y^2 - \frac{(\Sigma Y)^2}{N} \right) - \frac{\left(\sum \chi Y - \frac{(\Sigma \chi)(\Sigma Y)}{N}\right)^2}{\left(\sum Y^2 - \frac{(\Sigma Y)^2}{N}\right)} \]

2. The second adjustment, based on the within-sample sums of squares and products of deviations from the sample means by using formula

   \[ E_w = \left[ \sum Y_i^2 - \frac{(\Sigma Y_i)^2}{N_1} + \sum Y_i^2 - \frac{(\Sigma Y_i)^2}{N_2} \right] - \frac{\left[ \sum \chi_i Y_i - \frac{(\Sigma \chi_i)(\Sigma Y_i)}{N_1} + \sum \chi_i Y_i - \frac{(\Sigma \chi_i)(\Sigma Y_i)}{N_2} \right]^2}{\left[ \sum \chi_i^2 - \frac{(\Sigma \chi_i)^2}{N_1} + \sum \chi_i^2 - \frac{(\Sigma \chi_i)^2}{N_2} \right]} \]

3. The discrepancy sum of squares

   \[ D = E_t - E_w \]

4. The discrepancy variance, a measure of apparent treatment effects

   \[ V_d = \frac{D}{C - 1} \]

5. The error variance

   using the formula

   \[ V_e = \frac{E_w}{(N - C - 1)} \]

6. F-value for testing the significance of the difference between means
\[ F = \frac{V_d}{V_e^w} \]

7. Degrees of freedom (df)

(i) \( df \) for between samples or treatments (D) = \( C - 1 = 2 - 1 = 1 \)

(ii) \( df \) for within samples or error (\( E_w \)) = \( - C - N1 = 140 - 2 - 1 \)

(iii) \( df \) for total means (\( E_t \)) = \( N - 2 = 140 - 2 = 138 \)

8. The adjusted mean of the criterion test scores of the experimental group.

\[ M_{Y1,X1} = M_{Y1} - b \left( M_{X1} - GM_X \right) \]

9. The adjusted mean of the criterion scores of the control group

\[ M_{Y2,X2} = M_{Y2} - b \left( M_{X2} - GM_X \right) \]

\( M_{Y1} \) and \( M_{Y2} \) are the means of the scores on criterion test obtained by the subjects of the experimental and control groups respectively.

\( M_{X1} \) and \( M_{X2} \) are the means of the scores on the intelligence test obtained by the subjects of the experimental and control groups respectively.

\( GM_X \) is the grand mean of the scores on the intelligence test obtained by the subjects of the two groups.

\( b \) is the regression co-efficient

\[
= \frac{\sum XY - \left( \frac{\sum K \sum Y}{N} \right)}{\sum X^2 - \left( \frac{\sum X^2}{N} \right)}
\]

The following chapter deals with the analysis of data.