4.1. Introduction

Research methodology is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically. It is essential that the researcher must have sufficient knowledge both on methods and methodologies. Methodology helps the researcher to decide about the techniques to be utilized or applied in the study, because, certain techniques and procedures are applicable only to certain problems. Thus, it is necessary for the researcher to design the methodology for the particular problem very carefully. The scope of research methodology is wider than that of research methods. Thus, when we talk of research methodology, we not only consider research, but also the logic behind the methods we use in the context of our research study and explain why we are using a particular method or technique and why we are not using others, so that research results are capable of being evaluated either by the researcher himself or by others (Kothari, 1985).
This chapter deals with the methodology followed in this study. A systematic methodology is a must for any research investigation not only to analyse the problems properly but also to arrive at dependable and reliable conclusions. The methodology is a touchstone to assess whether the researcher has followed scientific procedures in his investigation. A clear-cut methodology will guide the investigation in the right direction without any deviation or distraction and haphazardness. So the investigator took utmost care to follow a scientific methodology in this investigation.

The methodology followed in this study is discussed under different headings namely development of CAI software for learning physics at plus one level, establishing the validity and reliability of the developed software construction of achievement test, establishing reliability and validity of the achievement test identifying various categories of students, selecting samples and sample design, application of the two CAI modes of instruction in the experimentation, scoring procedures, data collection and finally the statistical techniques used in the study for arriving at dependable conclusions.

4.2. Development of Computer Software for CAI

An earnest effort was made to develop computer software for CAI. A computer expert was consulted for the purpose and it was discussed with him how to develop software for CAI based on the selected concepts / units. Though there are various CAI programmes such as “drill and practice programme”, “tutorial programmes”, “generative programme”, “dialogue enquiry programme” and “simulation programme”, the investigator decided to follow the first two i.e., drill and practice and tutorial programmes since these are the most widely used types of computer programmes (Slavin, 1986).

Development of Software for Drill and Practice CAI

The most widely used type of computer programme is drill and practice. This application resembles other teaching techniques such as flashcards and programmed instruction. The software for drill practice
programme was developed with a view to provide practice on skills and knowledge so students can remember and use what they have been taught. The methodology involves repetition of a format in which the computer presents an exercise, the student types in a response, and computer informs the student if the answer is correct. Drill and practice programme was developed incorporating a linear structure. Linear programmes, which are derived from behavioral learning theories, present questions to the student, allow the student to respond, measure the correctness of the response, then move to another predetermined segment of instructional material.

**Development of Software for Tutorial CAI**

Tutorial CAI programme was developed so as to put the computer into the role of a teacher instructing an individual student. Their strength is that they actively involve the student in self-paced instruction. Some of the better tutorial programmes use the Socratic teaching method, in which the student’s learning is guided by a carefully sequenced series of leading questions. Tutorial CAI programme was developed incorporating branching structure. Branching programmes give students more information about their answers. These programmes present information in larger units, accept the student’s response, provide comments concerning the response, and either repeat the same sequence of branch or another appropriate one. The comments are designed to correct misunderstandings rather than “reward” or “punish.” These programmes present a preset body of knowledge in a systematic fashion.

Diagrams and sketches were also incorporated in the software in appropriate places through scanning procedure. For subjects and units different codes were allotted. The software was prepared in such a way that it ensured the following.

1) Letting students work at their own pace.
2) Providing immediate feed back and reinforcement
3) Measuring performance quickly and giving students information on their performance.
The software had to be developed in Tamil language since it was meant for Tamil medium students. Once the programming was over, it was subjected to tryouts. In the tryouts the students expressed that it was more conducive for learning at their own pace. Also, they found it more effective since the interaction with the computer had a motivating quality of its own. After this, the software for CAI programme was made ready for the use of the experimental group students.

**Validity of CAI Software**

The developed CAI software was submitted to a panel of experts. The panel consisted of two computer experts M. Sivabalarajan Director, Symphony services, Bangalore and C. Manoharan, Software Solutions consultant, New York, G. Lokanadha Reddy, Professor, Department of Education, Alagappa University, Karaikudi and Professor C. Sanjeevi Raja, head of the department of physics, Alagappa University, Karaikudi. The professors viewed the programme to assess the required requisites like adequacy of content, clarity and sequence. The computer software experts scanned the programme in terms of technical accuracy like programming, sequencing etc. The panel experts found the CAI software satisfying the requirements. The unanimous opinion of the experts was taken as the index of the validity of the CAI software.

**4.3. Identifying Various Categories of Achievers**

Individual differences among students are found on account of certain operating factors related to heredity and environment. But, when we analyse the learning process of students, we find individual differences emerging on three grounds namely entering behaviour, learning rate and learning style. If a teacher sets his pace of instruction according to the needs of his more able students, those with learning problems can never catch up. So there is a greater need to identify all the categories of students. i.e., high achievers, average achievers, under achievers and low achievers so that instruction can be accommodated to student differences.
As far as this study is concerned, the investigator has followed a two phase process to identify the various categories of students. They are

1) identifying phase

2) Scientific confirmatory phase

**Identifying phase:**

In the first phase, the various categories of achievers were identified on the basis of educational assessment as suggested by Tansley and Gulliford (1962), Chintamani Kar (1992) and Ramar (1996).

An educational assessment of the students brings to light the various types learners. This educational assessment was made with the help of the concerned class teachers who spend most of the time with those students, by direct observation and by scrutiny of relevant school records. This type of educational assessment provides a detailed description of the child in the school setting, giving information about eight factors.

1) The child’s level of attainment in the basic subjects in terms of what he can do and what his special difficulties appear to be.

2) The child’s level of language development and speech.

3) Standards of achievement in other areas of curriculum e.g. art, practical subject, physical education.

4) Emotional and social behaviour as displayed both in and out of the classroom.

5) Interest in and attitude towards school.

6) Previous school history.

7) The child’s interest and background knowledge.

8) Degree of parental co-operation.

By making an educational assessment of the target population by observation technique as well as by scrutiny of records, which gave a subtle insight into the students capacity and achievement, about 15 high achievers, 30 average achievers, 45 low achievers were identified in the first phase.
Scientific Confirmatory Phase

The various categories of achievers identified in the aforesaid manner were, then, subjected to a scientific confirmatory test. To classify the students into the above said four categories, the investigator administered Standard Progressive Matrices to them. Standard Progressive Matrices designed by Raven has been successfully and effectively used by Ramar (1996), Reddy & Ramar (1996, 1997) and Iqpal (2007) in Indian setting.

The Standard Progressive Matrices, sets A,B,C,D and E designed by J.C. Raven is a test of a person’s capacity at the time of the test to apprehend meaningless figures presented for his observation, see the relationship between them, conceive the nature of the figures completing each system of relations presented, and by so doing, develop a systematic method of reasoning.

The scale consists of 60 problems divided into five sets of 12. In each set, the first problem is as nearly as possible self-evident. The problems which follow become progressively more difficult. The order of the tests provides the standard training in the method of working. The five sets provide five opportunities for grasping the method and five progressive assessments of a person’s capacity for intellectual activity. Everyone is given exactly the same series of the problems in the same order and is asked to work at his own speed, without interruption, from the beginning to the end of the scale. A person’s total score provides an index of his intellectual capacity.

Standard Progressive Matrices test was administered to all the 103 students. The students were explained how to grasp each pattern. Apart from this, no assistance was given to the students in the method of working, as the standard order in which the problems are presented provides the necessary training.

The score obtained by each student and the time taken by each student to complete the test were noted down. In the confirmatory test, who got less score (9-15/60 or below 25th percentile point) were classified as low achievers. There were about twenty five students below the 25th
percentile point. Those who got score above 75 percentile point were classified as high achievers. Those who clustered around 50th percentile point were classified as average achievers. For all the selected students their scores in the half yearly examination were also noted down. It was interesting to note that about 21 students who had their scores above 50 percent in the standard progressive matrices, had scores ranging below 45 percent in the half yearly examination. Their academic performance in the half yearly examination was not in tune with their intelligence level. Their achievement was not befitting their capability. These students were classified as under achievers for the purpose of this study. Though there are Terman-Merill scale, Wechsler's intelligence scale etc., the investigator preferred standard progressive matrices since it is a non-verbal test which can be easily understood by the students.

4.4. Construction of Achievement Test

To evaluate the effectiveness of the two modes of computer assisted instruction and to compare the achievement of the plus one students taught through the two modes of computer assisted instruction with that of control group students, taught through traditional lecture method, an achievement test was constructed. The test was constructed covering the units chosen for this study. Equal weightage was given to each unit.

Questions of objective type nature were framed without omitting any unit. Multiple choice, fill in the blanks, true or false, and match the following were the types of questions used in this achievement test. The questions were framed so as to suit the level of plus one students. Utmost care was taken to avoid ambiguity and ambivalence. The items included in the final form of achievement test were selected on the basis of item analysis.

Initially 120 questions of objective type in nature were framed for tryouts. Forty percent multiple choice test items, forty percent fill in the blanks or supply test items and ten percent true or false test items and ten percent matching test items were framed for the achievement test. Multiple choice test items were composed of a stem followed by a series of
possible responses or options. The stem is a direct question or an incomplete statement with four options of which only one is the correct response. Due importance and weightage the investigator has given to multiple choice-test item because its level of difficulty can be varied with relative ease, and it is capable of reflecting simple student behavioural patterns such as recall of information as well as complex student behavioural patterns such as the ability to analyse and synthesise.

Supply test items or fill in the blank test items constitute 40 percent of the achievement test items. These test items are questions or incomplete statements which require highly short and specific answers. The answer is usually a significant word or expression. Matching test items consist of two lists of items and a set of instructions for matching one of the items in the first list with one of the items in the second list.

**Item Analysis**

After this pool of 120 test items was constructed, the framed test items were subjected to careful scrutiny and critical judgement by a panel of subject experts. Each item was critically examined for what might be termed “formal defects”. The next stage was tryout, the whole pool of items was given as a test to 20 students belonging to the target population. The obtained data were then used for an elaborate set of statistical procedures known as item analysis which gave the investigator information regarding, item difficulty, item discrimination and error or distraction analysis.

**Item Difficulty**

Test item difficulty refers to the percentage of students who provide correct answer to a given test item. The level of difficulty was determined by using the formula

\[
P = \frac{N_r}{N_t} \times 100
\]

Where  
- \( P \) = Percentage of students who answered the test item correctly  
- \( N_r \) = Number of students who answered the test item correctly
In most of the cases, the percentage clustered around the 50 percent level. On the basis of this analysis, too easy and too difficult test items were deleted in the final form of achievement test.

**Item Discriminating Power**

A test item is said to possess adequate discriminating power when it is capable of differentiating between superior and inferior students. To determine item discriminating power, the following simple formula was used even though there are many different computational schemes

\[ D = \frac{U - L}{N} \]

Where

- \( D \) = Index of item discriminating power
- \( U \) = Number of students in the upper group who answer the test item correctly (usually 27% of the total group)
- \( L \) = Number of students in the lower group who answer the test items correctly (usually 27% of the total group)
- \( N \) = Number or students in each group.

For more than 50 percent of the test items, the computed \( D \) value exceeded +0.4 which indicated that the test items were good and for the remaining items, the computed ‘\( D \)’ value ranged between +0.40 and +0.20 which was a clear indication to the satisfactory condition of the test item. Those items which failed to differentiate between the superior and the inferior students were not included in the final form of achievement test. The P-value and D-value for each of the 120 test items in the initial form of achievement test were calculated and are provided in Appendix-I. The final form of achievement test consisted of 100 test items and it is given in Appendix - II and the English version of the achievement test is given in Appendix - IV.

Each item was scored ‘one’ mark for the correct response and ‘zero’ mark for the wrong response. The duration of the test was 2 hours. The
same achievement test was used as pre-test and post-test and retention test in the study for all the three groups mentioned in the study.

**4.5.1. Reliability of the Achievement Test**

Then a pre-testing was made administering the test to twenty students belonging to the target population. The main purpose of the pre-testing was to establish the reliability of the achievement test. The scores obtained by the students in the pre-testing formed the basis for establishing reliability of the test.

**Reliability of the Tool Used**

The test reliability means the consistency with which a set of test scores measures what they do measure (Ebel, 1975). It relates to the accuracy with which skills and knowledge are measured (Slavin, 1987). Reliability is a necessary condition for validity. Reliability co-efficient provides the most revealing statistical index of validity that is ordinarily available.

There are different methods to estimate the reliability of a test. Some of the commonly used methods are:

1) Test – retest reliability
2) Split half reliability
3) Alternative parallel form reliability and
4) Kuder – Richardson Estimates.

In the present study, the split half method is used to estimate the reliability of the test. The split half method is considered to be one of the best methods for measuring reliability because all the data for computing reliability are obtained by one testing. Also, the variations likely to be brought about by difference between the two testing situations are eliminated.

The test was conducted to twenty plus one students. In this method, the test items were divided into two equivalent halves by pooling the
scores on odd numbered items and then pooling the scores on even numbered items, and the correction was found for these half tests by using the Karl Pearson’s correlation coefficient formula,

\[ r = \frac{N\sum XY - \sum X \sum Y}{\sqrt{(N\sum X^2 - (\sum X)^2)(N\sum Y^2 - (\sum Y)^2)}} \]

\[ = \frac{20 \times 9894 - 431 \times 434}{\sqrt{[20 \times 9987 - 185761]} \sqrt{[20 \times 10096 - 188356]}} \]

\[ = \frac{197880 - 187054}{\sqrt{199740 - 185761} \sqrt{201920 - 188356}} \]

\[ = \frac{10826}{\sqrt{13979} \sqrt{13564}} \]

\[ = \frac{10826}{13769} \]

From the reliability of half test correlation, the self-correlation of the whole test is than estimated by using Spearman-Brown’s Prophecy Formula.

\[ r = 0.88 \]

\[ r_{xx} = \frac{2 r_{oe}}{1 + r_{oe}} \]

\[ = \frac{2 \times 0.78}{1 + 0.78} \]

\[ = \frac{1.56}{1.78} = 0.88 \]

\[ r_{xx} = 0.88 \]

Where \( r_{xx} = \) coefficient of Internal consistency

\( r_{oe} = \) coefficient of correlation between the odd-half scores and even-half scores.
The obtained $r_{xx}$ value indicated that coefficient of internal consistency is high and positive. The obtained value 0.88 shows that the achievement test used in the study is highly reliable.

4.5.2. Validity of the Achievement Test

A research tool is said to be valid when it measures what it purports to measure. Any achievement test should possess validity. Validity indicates how adequately the content of the test is sampling that domain about which inferences are to be made. It is particularly very important for achievement test. A logical examination of instructional objectives and the contents to be taught was done by a panel of experts. The panel consisted of one professor in education, one professor in physics and four noteworthy P.G. Assistants of Rajapalayam taluk in addition to the P.G. Teachers serving in the school where the experiment was carried out. The ten experts scrutinised the achievement test to establish content validity, construct validity and face validity.

The developed CAI CDs were also viewed by the same panel of experts. The experts who viewed the CAI software expressed their view that the CDs would be easier than the text book. Also, they were of unanimous opinion that the applied CDs were relevant to the instructional content and they had the anticipated aural and visual effect besides having a motivating quality of their own. The agreement of the views of the panel experts was taken as the index of validity of the developed CAI software in terms of content and coverage.

4.6. Sample of the Study

The primary purpose of research is to discover principles that have universal application, but to study a whole population to arrive at generalizations would be impracticable, if not impossible. Some populations are so large that their characteristics cannot be measured, before the measurement could be completed, the populations would have changed. Hence the need for sample. A sample is a small proportion of a population selected for observation and analysis. By observing the characteristics of sample, one can make certain inferences about the
characteristics of the population from which it is drawn. Contrary to some popular opinion, samples are not selected haphazardly; they are chosen in a systematically random way so that chance or the operation of probability can be utilized.

Fortunately, the process of sampling makes it possible to draw valid inferences or generalizations on the basis of careful observation of variables within a relatively small proportion of the population. A measured value based on sample data is a statistics. A population value inferred from a statistics is a parameter.

For the purpose of this investigation, 90 students were selected from S.S. Hindu Nadar Higher Secondary School, Muhavur to represent rural school. All the students were taken from the plus one classes of the higher secondary course. The selected students had physics as one of their subjects in the prescribed syllabus. All the students selected were from rural areas belonging to middle and low-income group. The selected students were equally divided into three groups to form two experimental groups required for the study and the control group. Likewise, 90 students were selected from NAAR Memorial Hr. Sec. School, Rajapalayam to represent urban school. They were also divided into three groups as mentioned above.

4.6.1. Description of the Sample and Sampling Technique

To select the 90 students required for the sample, the investigator initially selected all the 103 students studying physics in plus one course. These students had to be classified as high achievers, average achievers, under achievers and low achievers. All the categories of achievers were identified on the basis of a two phase process as discussed earlier. After educational assessment and administration of Standard Progressive Matrices, 18 high achievers, 38 average achievers, 16 under achievers and 33 low achievers were identified.

Out of the 18 high achievers, 38 average achievers, 16 under achievers, 36 low-achievers, irregular students and the long absentees
were deleted as they were not able to undergo experimental treatment regularly. Excluding such students from the list, 15 high achievers, 30 average achievers, 15 under achievers and 30 low achievers were selected for the purpose of this study. The urban students were also identified and selected in the aforesaid manner. The students in each group were placed in the order of merit and they were equally and randomly allotted to groups as shown below.

1  2  3  
6  5  4  
7  8  9  
12 11 10

This systematic purposive random sampling technique was used to avoid clustering of highest mark in a block of three in group I or in the first group and lowest mark in a block of three in the last group. The same procedure was adopted for allotting the under achievers and low achievers to each of the three groups formed for the purpose of this study. The students were placed in the order of merit based on their performance in the half yearly examination, and on the basis of their scores in Raven’s Progressive Matrices. Out of the three formed groups, two groups constituted the experimental groups and the remaining one was control group. Experimental group I was taught through drill and practice CAI, the experimental group II was taught through tutorial CAI and the control group was taught through the traditional lecture method.

4.6.2. Procedure for Equating the Groups

The sample of 90 students was divided into three groups of 30 students each. The three groups were equated as nearly as possible in terms of their achievement scores in the half yearly examination. Students having the same range of marks in the half yearly examination were equally and randomly allotted for experimental group and control group. To find out whether the control group and the experimental groups were matched ones or not, mean and standard deviation were calculated for the
scores obtained in the half yearly examination by each group. Then t-test was applied to the scores of the control group and the experimental groups. The obtained t-values (0.43, 0.51, 0.44) were found to be not significant at 0.05 level. Hence the three groups were matched ones in terms of their achievement before the inception of the experimental study.

Also t-test was applied to the pre-test scores to verify, whether these groups were matched ones. The obtained f-value (0.072) was not significant at 0.05 level. Thus the f-value also revealed that the three groups were matched ones before the inception of experimentation.

4.7. Implementing Drill and Practice and Tutorial CAI Programmes

The experimental group-I was taught through drill and practice computer assisted instruction. The experimental group-II was taught through tutorial CAI programmes. The CAI software was used for the benefit of the students in the experimental groups. The students had some problems initially with the code number and with the keyboard. Though they did not know how to handle the keyboard, they picked up the modus operandi in a week or so.

Since CAI software had a motivating quality of its own, due to the provisions for interaction by students, they were very much attracted to it. The provision for knowledge of result, immediate feedback and reinforcement found in the CAI programmes made their learning exciting and pleasant. As in the printed text, there was no need for the students to scan the text to find out the correct response. The correct response was furnished by the computer itself in the CAI programme. The diagrams and the sketches which were incorporated in the CAI software through scanning procedure, made good visual impact which, in turn, promoted better understanding and longer retention. In this strategy, the teacher support system was restricted to the extent of guiding the students in computer operation.

The last group was control group and the control group was taught through traditional lecture method. The experimental group students were
subjected to special treatment for a period of 90 days at the rate of one hour per day. After the period of this experimentation, a post-test was conducted to all the three groups in rural and urban schools. To measure the efficacy of these modes of instruction in retention of information acquired by the students, a retention test was also conducted after a lapse of 45 days.

4.8. Data Collection

At the end of the experimental period, a post-test was conducted to the students of the experimental groups and the control group. Exactly 45 days after the post-test, a retention test was administered to all the three groups to measure the degree of retention with regard to each mode of instruction. The responses given by the students in the pre-test, post-test and the retention test formed the vital data required for the analysis. The scores of the three groups in the pre-test, post-test and the retention test are given in Appendix -VI.

4.9. Scoring Procedure

The achievement test consisted of 100 objective type questions. The total score of test is 100. For each correct answer, the score is one and for each wrong answer the score is zero. The answer key to the achievement test is given in Appendix-III. Key to the English version of the achievement test is given in Appendix – V

4.10. Statistical Techniques Used in the Study

Statistics is a body of mathematical techniques or processes for gathering, organizing, analyzing, and interpreting numerical data. Because most research yields such quantitative data, statistics is a basic tool of measurement, evaluation, and research. The word statistics is sometimes used to describe the numerical data gathered. Statistical data describe group behavior or group characteristics abstracted from a number of individual observations that are combined to make generalizations possible.
Research consists of systematic observation and description of the characteristics or properties of objects or events for the purpose of discovering relationships between variables. The ultimate purpose is to develop generalizations that may be used to explain phenomena and to predict future occurrences. To conduct research one must establish principles so that the observation and description have a commonly understood meaning. Measurement is the most precise and universally accepted process of description, assigning quantitative values to the properties of objects and events. This envisages the need for applying appropriate statistical techniques to analyse the data obtained by means of pre-test, post-test and retention test.

The data thus obtained were analysed using appropriate statistical techniques such as mean, standard deviation and F/t-test. In the first stage, mean and standard deviation (SD) of pre-test scores were calculated for all the three groups of students.

In the next stage, to know the effectiveness of the two modes of computer assisted instruction in teaching physics at plus one level, mean and SD were calculated for the post-test scores in respect of all the groups. Based on the mean and SD, F/t-test was calculated to know the significant difference, if any, among the groups and/or between any two groups. The same calculation was applied to retention test also. When the comparison was between two groups, t-test was applied to verify whether there is any significant difference between the two groups. When the comparison involved more than three groups, F-test was applied to verify whether there is any significant difference among the groups. Whenever, F-value was sound significant, t-test was again applied to establish between which two groups there was significant difference.

The obtained results and interpretations are presented in the succeeding chapter-V.