### CHAPTER IV
**METHODOLOGY**

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CHAPTER IV

METHODOLOGY

INTRODUCTION

Research is simply a systematic and refined technique of thinking, employing specialised tools, instruments and procedure in order to obtain a more adequate solution to a problem. The consequent utility of a research mainly depends upon the method selected for the investigation. Research methods refer to techniques that the researcher uses in performing the research operations.

Methodology is the science of appropriate modes and order of procedures. Methodology aims at making the study systematic. A suitable method helps the researcher to explore the diverse stands of the study and adequately measures them so as to satisfy the requirements. The method of investigation should be brief and suitable to the problem selected. The methodology should answer the questions such as the materials used in the study, development and validation of the tool used, the source of the data, procedure for data collection and the analysis of data. The decision about the method depends upon the nature of the topic, purpose of the study and the type of the data required. The above methodological considerations are carefully adopted and presented in the present chapter.

Based on the above, the investigator decided to adopt an experimental design which has intervention of programmes like, Lecture Method, Computer-Assisted Instruction and Computer-Assisted Instruction with Peer Interaction. In this chapter, an attempt was made to describe the development and validation of the CAI packages in Physics, the development of criterion referenced tests in Physics, the procedure adopted in the construction of “Self-Regulated Learning Scale”, the sample of the study, method of data collection, the mode of experimentation and the analysis of data.
The success and development of computer-assisted instruction largely depends upon three components viz. instructional strategy, screen design and human factors. By designing curriculum based courseware around these three components, educators can translate new technological development into teaching- learning process. This curriculum based design approach enables educators to organize, develop and implement effective learning tools. A good educational software not only tries to teach but should provide a stimulus for the learning experience. Hence, the teachers and courseware designers must infuse curriculum-based learning packages.

While developing the instructional packages the investigator had a thorough analysis of the eleventh standard Physics text book and identified the units and modules which are suitable for development of CAI packages. He also had a discussion with the Physics teachers, computer experts and educational technologists while planning for the teaching software in Physics. Consequently, he selected five syllabus based content areas in Physics viz. Laws of Motion, Wave Motion, Elasticity, Semiconductors and Semiconductor Diode.

An educational software should satisfy the needs of individual learners. At the higher level of education, learners need an instructional software which instructs a conceptual information according to their own pace of learning. Tutorial software can also help to satisfy the different needs and may serve as a remedial function. According to Alesandrini (1987), a tutorial orients the learner to the lesson, provides instruction and opportunity to apply what is learned, provides feedback designed to correct errors, fosters learning and assists the learner to generalize the new information. Hence, it is decided to develop a syllabus based instructional software packages in Tutorial method.
TUTORIAL INSTRUCTION ALGORITHM

A tutorial consists of sequences that provide instructions, that guide learning, check comprehension, remediate as necessary, then move ahead. The Tutorial Instruction Algorithm is shown in the Figure: 4.

In the Figure: 4, the decisions that determine “next sequence” can be very complex. The next sequence need not, indeed should not, be identical for all learners. Remediation may also differ among learners. In some tutorials, remediation means re-presenting the exact information as the first time (Lockard, 1992).

FIGURE: 4 TUTORIAL INSTRUCTION ALGORITHM (LOCKARD, 1992)

![Tutorial Instruction Algorithm Diagram]

Characteristics of Tutorials

Tutorials are intended to assume the major instructional responsibility perhaps similar to what a live tutor might do. The purpose of tutorial CAI is to provide initial or remedial instruction directly. Tutorial CAI becomes synonymous with self-contained individual instruction. A Tutorial can be available at the learners' discretion rather than on a fixed schedule, making learners compatible with other activities. The main characteristics of the Tutorials are as follows:

1. Tutorials presume no prior knowledge of the major content.
2. They may be used to introduce a new content.
3. Tutorials are also suitable for review or reinforcement.
4. They may be intended for learning without a teacher.
5. Tutorials present information, then guide the user in applying it.
6. They provide only a limited amount of practice and assessment.

Pedagogical Principles involved in the Tutorials

Tutorials involve more pedagogy than Drills or Simulation. Methods and strategies are highly diverse they considered to be more important in the pedagogic scenario. Bell (1985) has identified the type of skills taught by tutorials, the related instructional strategies and the instructional criteria. They are as given below:-

Skill-1: Concrete concepts

Tutorials are useful in teaching the concrete concepts in which information processing theories are employed. The instructional criteria involved in this process are:-
1. Providing links to prior learning.
2. Presenting examples for each defining characteristics.
3. Presenting examples from simple to complex.

Skill-2: Abstract concepts

Abstract concepts are also taught through tutorials which also involve the information-processing approach. The instructional criteria used here are:-
1. Providing links to prior learning such as advanced organizers.
2. Presenting illustrative examples.
3. Including opportunities for learners to develop a network through open-ended examples and questions.
4. Providing comparisons and contrasts with other concepts.

Skill-3: Rule application

Rule application can be taught through tutorials. This involves Gagne's types of learning in which intellectual skills are the higher order of learning. The instructional criteria involved in the teaching of rule application are:-
1. Providing recall cues for relevant concepts and information.
2. Providing verbal cues so that students combine concepts in a new rule.
3. Asking students to add one or more examples of the rules.

Skill -4: Problem solving
It is possible to teach the problem solving method through tutorials which also includes the Gagne's types of learning. The instructional criteria adopted in this process are:-
1. Providing cues for recall of pre-requisite rule.
2. Presenting new problem to the learner.
3. Providing cues to lead the learner to synthesise hypotheses to one or two promising ones.
4. Providing redirection when needed.

THEORETICAL CONCEPTIONS ABOUT A GOOD SOFTWARE
The computer software can turn a computer into an effective instructional device. It has to be selected with care. The criteria for the selection of a software as suggested by Purushothaman and Stella (1995) are discussed as given below:-

1. Content
For the CAI software to be effective in a learning situation its content should have educational value. It should be accurate and free from errors. It should also be free from racial, sex or ethnic bases. In this study, it was decided to develop a syllabus based software packages for teaching Physics at Std XI.

2. Objectives
The purpose of the software should be well defined and the software should be capable of achieving the same. Also, the software should be consistent with the objectives of the curriculum. That is why, the instructional objectives for each of the content areas were stated (In Appendix: 1) and the programmes were developed so as to achieve the objectives.
3. Specification of the target group

Some programmes may have a specific target group and some may need minimum skills on the part of the learners. Here, the target group is eleventh standard students studying Mathematics, Physics, Chemistry and Computer Science as optional subjects. Since the computer science has already been included and taught as a curricular subject, it is obvious that they possess adequate skills in the operations of computers.

4. Text, Graphics and Sound

Each screen display should have been carefully planned to have the maximum effect. The use of the graphics should be appropriate. If sound effects are included they should constitute an essential and integral part of the programme. Keeping these features in mind the software packages were developed in VISUAL BASIC besides being suitable to the colour monitor. Since, the visual basic packages are more user friendly, easy for programming and easily attracts the attention of the pupils, it was decided to develop the programmes in the Visual Basic language.

5. Flexibility and User friendliness

The programme should be user-friendly and flexible. That is, it should be easy and convenient to use. It should help to choose options. Keeping these points in mind, the options are provided to enter, to move and to quit the programme. Also, options are provided in such a way that the student can use either the tab key or the mouse. Further, options are provided to answer the questions either typing a short word or choose the best one from the options given.

6. Feedback

Learner feedback is perhaps the most vital aspect of a good programme. Hence, the correct feedback is provided at each step of the response of the learner. The option for feedback is provided in such a way that if the learners are not able to answer the question, then they have to read the same frame again for remediation. Again they have to answer the same question. Unless they answer the question correctly, they can not move to the next frame.
7. Reinforcement

A correct response needs to be rewarded. However, incorrect responses can be ignored, in the sense that negative reinforcement is not necessary. Hence, in the question-answer frames, no negative reinforcement has been included.

8. Individualisation

The main advantage of a computer programme lies in its potentiality to teach the learner individually. It should allow the learners to proceed at their own pace. The programme therefore, has been developed to suit the needs of the learner.

9. Progress Record

A programme should keep the record of the learners' progress. Facility to find out the total time taken by an individual in completing the given package or at which frame he has quit from the package was introduced in the packages developed.

The tutorial programmes were developed in such a way that they fulfill all the above nine criteria. The programme development is discussed in the succeeding pages.

DEVELOPMENT OF TUTORIAL PACKAGES

The software package developmental model involving five phases suggested by Lockard (1992) has been adopted in this investigation. It is often called as Analyse - Design - Develop - Implement - Evaluate (ADDIE) model. The tutorial development model as conceived by the researcher is shown in Figure: 5. The steps involved in the development of the computer software packages as noted below.

Phase I: Analyse Phase

This phase includes the development of instructional problem, writing the instructional objectives and the development of content.

In this phase, the instructional problem has been decided. The instructional objectives for the selected contents have been written and the instructional objectives and content analysis for the five content areas are given in Appendix: 1 and Appendix: 2. The materials for the tutorial package from the selected content areas have been written in the format of programmed learning package. The package prepared was submitted to the
opinion of the Physics teachers handling eleventh standard and as per their suggestions, the content was modified appropriately.

**Phase II: Designing Phase**

This phase includes the decision about the events of the instruction, preparing the structure charts, developing the flow charts of the programme and designing the screen.

The decision about the events of instruction includes motivating the students, presenting the objectives, presenting the material, guiding the learning, leading the performance, providing feedback and assessing the achievement. These steps have been carefully adopted in preparing the learning materials. The sequence of presentation is shown in the structure charts. The structure charts revealing the sequence of presentation of the content is given in the Appendix: 3. Next, the flow charts are developed (Appendix: 4). Then, the screen design was decided. It was decided to present the textual materials in the first half of the screen, the figures at the left side of the second half. The keys to move forward and backward and quit the programme were to be presented at the right side of the second half of the screen. The user guide to handle these packages is given in the Appendix: 5.

**Phase III : Development Phase**

This phase includes the development of the programme, preliminary administration (Pilot Study) and revision of the programme.

The syllabus-based content material has already been written and planned in such a way that each frame has a concept/subject matter. The inclusion of questions has also been decided. Then the software was coded in Visual Basic Language with the help of a computer expert. Then it was debugged and tested. The programmes thus developed were taken for pilot study. A small group of eleventh standard students was used for this study. The investigator observed the problems faced by the students in the learning process. Besides, he had a discussion with them subsequently and on the basis of the feedback the software had been finalised with suitable modifications.
Phase IV: Implementing Phase

The software developed by the investigator was availed to the intended population. The investigator has availed these software packages to the experimental group I and II as an experimental intervention. The effect of this instructional software packages particularly the mastery of content among the learners was measured by the criterion referenced tests in Physics developed by the investigator.

Phase V: Evaluation Phase

The software material was evaluated in this phase. For this purpose the investigator has developed a "Courseware Evaluation Proforma". The proforma was supplied to the Physics teachers, computer experts and educational technologists. The development of the Courseware Evaluation Proforma has been discussed in the succeeding section.

Beside being a subject expert in Physics, the investigator possesses teaching experience in the same subject at Higher Secondary stage. With his expertise and experience, five packages in Tutorial mode were developed in the Physics syllabus prescribed for Std. XI in the content area such as Laws of Motion, Wave Motion, Elasticity, Semiconductors and Semiconductor Diode. A few print outs of the syllabus-based software packages is given in the Appendix: 6.

COMPUTER COURSEWARE EVALUATION

Computer assisted presentations have a powerful potential to aid in the conveyance of information within a professional setting. Educational software has been improved over the last several years as developers have taken advantage of increasing computer abilities. Unfortunately, these technical advances have not created the theoretically sound and educationally valid software needed for the schools. It was observed that many teachers were dissatisfied with the quality of design and presentation strategies used in the preparation of all types of courseware. It is assumed that this dissatisfaction, at least in part, stems from the lack of adequate programme evaluation prior to its application in the classroom. (Ilisa Schwarz and Molly Lewis, 1989).
In order to successfully address the problem of poorly designed or presented software programmes, all educational courseware should be examined by a thorough and detailed system of evaluation. If the computer-technology is not well planned and used effectively, then the technology will become a distraction from the overall message and the content of presentation.

While evaluating the computer software packages, experimental methods have proved increasingly difficult to implement and lack the capacity to generate detailed results. The rigid nature of the experimental design restricts the scope of investigations and the conditions in which studies can be conducted. Over the past five years, a customizable evaluation framework has been developed specifically for computer assisted learning research. Hence, it was decided to develop a courseware evaluation proforma to evaluate the developed software in Physics. The modified version of the proforma developed by Rangaraj (1995) has been used to evaluate the packages in this study. A model of computer courseware evaluation as used by the investigator in the form of flow is shown in the Figure: 6.

Development of Courseware Evaluation Proforma

The development of courseware evaluation proforma involves five stages.

1. Objectives of the Programme

The objectives of the programmes should be based on the demands of the learners. The objectives should also well suit to the learners level and interest. It should be relevant to the syllabus prescribed for the learners. The objectives should also be stated in behavioural terms.

2. Content

This involves two dimensions.

a) Thematic content: Thematic content should be based on the scientific facts, exact and verifiable information and free from errors. The information should be simple avoiding overloading. The up-to-date information may also be included. If possible several explanations may be given for some difficult concepts. Hence, the thematic
content should be matched to the students' age and interest and it should be written according to the instructional objectives.

b) **Linguistic content:** The linguistic nature of the content material is also important. The materials should be presented in the simpler terms. Loose and ambiguous statements should be avoided.

3. **Design of the Material**

   The materials for the programme should be developed according to the needs of the learners. The materials should also suit to the task expected by the learners. There should be a guidance section in the programme so that the learner can overcome the difficulties during their study. It should fulfill the criteria expected of the material. The materials should match with the computer medium. Irrelevant matching of the material should be avoided.

4. **Instructional Strategy and Process**

   This involves four dimensions.

   a) **Learning experience:** The learning experiences provided by the package should be intrinsically interesting so that it will motivate the students. The experiences should go hand in hand with the learning materials. Overloading of unwanted materials for the sake of developing a lengthy programme should be avoided. The time limit should also be optimum. If the programme is for a long duration, the learners will lose their interest and will develop fatigue. Similarly, monotony in the presentation should be avoided.

   b) **Evaluation:** There should be a provision for the students to evaluate their own performance while studying the material. Hence, the questions to test the critical awareness of the learners should be asked during presentation of the programme. The questions should be based on the appropriate instructional design and the content to be taught. There should be clarity, simplicity and appropriateness of content in questioning.
c) Feedback to Learners: Appropriate feedback should be provided in the programme at every step of their responses. The direction for continuous progress in learning is controlled by the constant feedback given to a learner in the process of learning.

d) Examples during Presentation: The examples should be provided in the programme at the appropriate places. If needed, an additional material can also be used while presenting the examples. It should be based on the previous knowledge of the
students and must be suited to the content. It should be properly provided during the presentation of the content.

5. Computer Potentialities

The computer potentialities which mainly involve three dimensions should be used to the maximum extent possible.

a) Screen Design: The screen should be designed after a thorough analysis being carried out with the help of the computer experts. The screen design should arrest the attention of the learners. The frame size and length should be very precise and clear. If possible, make use of the colour facilities. A help menu should be provided in the screen.

b) Role of Computer: The computer facilities being availed should suit to the pupil's preferences. It should be used in accordance with the methodology. The computer medium should well suit to the materials.

c) User Friendliness: The language used in the instruction of the programme should be simple, brief and clear. A good programme will always contain routines which check inputs/learner responses to make sure that they are within the expected range. The software evaluation proforma developed by the investigator with the respondents' evaluation is given in the Appendix: 7.

VALIDATION OF THE SOFTWARE PACKAGES

Instructional material is a tool in the hands of the educator. The process of selecting instructional materials should be systematic so that it will help to improve the quality of education. Computers can improve education only if they are used with the right type of software. The need to select good computer software may even be more difficult than that of choosing the printing materials because, such software is often used independently off teacher control. Hence, the investigator intended to estimate the quality and suitability of the computer packages developed by him.

The content validity of the developed CAI packages should be assured with the help of the subject specialists since, it helps the investigator to confirm the sequencing and logical order of CAI presentation. The distinctive nature of modes of presentation
is also confirmed with the subject experts. The difficulty level of the five content areas were also rated with the help of the practicing teachers.

All the five computer packages developed by the investigator were evaluated using the "Courseware Evaluation Proforma" developed for this purpose. This process involves 30 experts comprising Physics teachers, computer specialists, software developers, and educational technologists. The investigator personally met the experts and provided the demonstration of the developed programmes. Then, the evaluation proforma was supplied to the experts. The experts were requested to register their opinion in a three point scale. The percentage score of their response was calculated.

From the evaluation of the experts, it was found that 100% of the respondents were of the opinion that the objectives of the programmes were relevant to the prescribed syllabus; Questions provided during the presentation were suited to the instructional objectives and the instructions provided for the usage of the programme were brief and clear. More than 95% of the respondents were of the opinion that the objectives of the programmes were useful / relevant to the students, the thematic content was suited to the instructional objectives; the design of the learning material was matched to the objectives of the programme; the learning experiences were suited to the objectives of the programme with suitable length and time duration; there were clarity in questions which occurred at appropriate places; the feedback given to students during presentations was appropriate; the examples provided during the presentation were suited to the content; the screen was designed properly; the role of the computer was matched to the objectives and the language used for the instruction through the programme was appropriate to the level of the learners.

Also, it was found that more than 90% of the respondents were of the opinion that the thematic content was matched to the students' age and interest; the design of the learning material fulfilled the criteria expected of the material and the feedback provided was appropriate to the instructional objectives. Further, it was found that more than 85% of the respondents were of the opinion that the objectives of the programmes were scientifically clear; the thematic content was matched to the students' age and interest; the linguistic aspects of the content of the programme was clear; the
design of the learning material was suited to the task expected of the learners; the learning experiences were matched to the learning material, students ability and computer medium; the examples given during presentation were proper and suited to pupils' previous knowledge and the computer medium was compatible in its role.

It was found that more than 80% of the respondents were of the opinion that the objectives of the programmes were apt to the students' entry behaviour; the thematic content was intrinsically interesting; the design of the learning material was matched to the computer medium; the learning experiences were intrinsically motivating; the feedback provided to the learners were suited to pupils' sustained progress and the screen design arrests the attention of the pupils. Moreover, it was found that only negligible amount of the respondents were of the opinion that the some of the features of the programmes were adoptable.

It is quiet impressive to note that, no one was of the opinion that any feature of the programme was not suited. This ensures that the quality of the software is "good" and suited to the teaching of Physics at Std. XI. After a thorough validation, all the five syllabus-based instructional packages developed by the investigator was used in the present study. The packages are given in the CD at the end of the thesis.

DEVELOPMENT OF CRITERION- REFERENCED TEST IN PHYSICS

Classroom testing plays an integral role within a number of instructional models. One commonly discussed model is "Mastery -learning". Mastery learning is simply an extension of conventional group instruction. To use a mastery learning strategy, one must be able to determine specifically what each student can do and cannot do. In a mastery learning assessment, when students' scores are interpreted with reference to that of the other students, the test is called as norm-referenced test. On the other hand, if the specific skill that a test measures is well-defined then evaluating a student's performance on the test indicates whether further instruction in this skill is appropriate. In fact, a student's performance on a test that measures a specific well-defined skill can be interpreted even if scores from other individuals are not available. When students' scores are interpreted with reference to a well-defined skill, the test is called a criterion-referenced test (Oosterhof, 1990).
Criterion referenced tests (CRT) are constructed to permit the interpretation of examinee's test performance in relation to a set of well-defined competencies (Popham, 1978). Criterion referenced means that a score is being interpreted in terms of the skills the test measures. To permit a criterion referenced interpretation, the description of what is being measured does not necessarily have to be elaborate, but it must be concise. Hence, it is clear that the items in the CRT should measure a well-defined domain of skills or competencies.

In a CRT, items are organised into clusters with each cluster serving as a representative set of items from a clearly defined content domain measuring an objective (Hambleton, 1982). CRTs provide information which is valued by test users but different from the information provided by the norm-referenced tests. There are three additional points to be considered about CRT.

1. The number of competencies measured by a criterion referenced test will (in general) vary from one test to the other.
2. The number of test items measuring each competency and the value of the minimum standard will (in general) vary from one competency to the other.
3. A common method for making mastery-non mastery decisions involves the comparison of examinee's percentage scores with competencies to the corresponding minimum standards.

Advantages of CRT over Norm Referenced Tests

1. Test purpose

CRTs are constructed to assess examinee's performance in relation to a set of competencies. Scores may be used to describe examinee's performance, to make mastery-non mastery decisions and to evaluate program effectiveness. Scores can be used to compare examinee's but comparisons may have relatively low reliability if score distributions are homogeneous.

2. Area of content specificity

CRTs are designed in such a way that the areas of content are specified clearly. Hence, the scores can be interpreted in the intended manner by the investigator.
3. Area of test development

The items in the norm-referenced tests have been selected using the item statistics (difficulty value and discrimination index). In CRTs, items are deleted from the pools of test items measuring competencies when it is determined that they violate the content specifications or standard principles of item writing or if the available item statistics reveal serious non-correctable flaws. Item statistics can be used to construct a parallel form of a CRT or to produce a test to discriminate optimally between masters and nonmasters in the region of a minimum standard of performance on the test score scale.

4. Score generalisability

Score generalisability is usually of interest with CRTs. When clearly specified competency statements are available and by assuming the test items are representative of the respective content domains, examinee's test performance can be generalised to performance in the larger domains.

Applications of CRTs

1. Classroom teachers use CRT scores to locate the students achievement in school performance, to monitor student progress and to identify student deficiencies.
2. Special education teachers are finding CRT scores especially helpful in diagnosing student learning deficiencies and monitoring the progress of their students.
3. CRT results are also being used to evaluate various school programmes.
4. While it is less common, CRTs are finding some use in higher educational programmes based on the mastery learning concept.
5. CRTs are used commonly in military and industrial training programmes.
6. Nowadays it has become common for state departments of education and educational districts to define sets of skills or competencies which students must achieve in order to be promoted from one standard to the next. In this kind of assessments, CRTs are found to be useful.
Steps involved in the development of CRT

While developing CRT, it is essential to specify very clearly the domain of content or behaviours defining each competency which is to be measured in the test constructed. The mechanism through which the competencies is identified will vary from one situation to the other. When CRTs are needed in an objective-based instructional programme, it is common to define a curriculum in broad areas. Then, within the cells of the grid, the sets relevant to objectives, often stated in behavioural form are specified, analysed, reviewed and revised. A set of 10 steps involved in the preparation of criterion-referenced test is given below. The steps involved in the development of CRTs are shown in the Figure: 7. Most of the steps are adopted from the steps suggested by Hambleton (1988).

Step 1: Preliminary considerations

This step is essential, to ensure that a test development project is well-organised and important factors which might have an impact on test quality should be identified early. This step involves the four stages.

a) specification of test purposes
b) specification of groups to be measured and special testing requirements (if any)
c) Determination of the time and money available to produce the test
d) Specification of an initial estimate of test length.

Step 2: Review of competency statements

Domain specifications are invaluable to item writers when they are well done. Considerable time and money can be saved later in revising test items if item writers are clear on what it is and that it is expected of them. This step involves two stages.

1. Review the description of the competencies to determine their acceptability.
2. Make necessary revisions in competency statements to improve their clarity.
Step 3: Item writing

The item writers should be provided some training in order to understand the importance and use of domain specifications and the principles of item writing. This step involves two stages.
1. Draft a sufficient number of items for pilot-testing.
2. Carry out item editing.

Step 4: Assessment of content validity

Items are evaluated by reviewers to assess their match to the competencies, their technical quality, objectivity from bias and stereotyping. It involves three stages.
1. Identify a sufficient pool of judges and measurement specialists.
2. Review the test items to determine their match to the competencies, their representativeness and their freedom from bias and stereotyping.
3. Review the test items to determine their technical adequacy.

Step 5: Revisions of test items

Any necessary revision to test items should be made at this step and when additional test items are needed they should be written. This step involves two stages.
1. On the basis of the data from the step 4(2) and 4(3), revise the test items (if necessary) or delete them.
2. Write additional test items (if needed) and repeat step 4.

Step 6: Field test administration

At this step the test is to be tried out on a limited number of students, to get a fix on the elements in the instruction which might be proved drastically wrong. One team member of the developers may accompany the subject teachers, in order to meet queries if any, relating to the content or procedure that might arise during the try out of the test. This is possible only if the member who is conversant with the development of the test is associated in the field try out.
FIGURE 7 STEPS IN THE DEVELOPMENT OF CRITERION-REFERENCED TEST

1. Preliminary Considerations
2. Review of Competency Statements
3. Item Writing
4. Assessment of Content Validity
5. Review of Test Items
6. Field Test Administration
7. Revisions to Test Items
8. Test Assembly
9. Using Test in Classroom
10. Establishing Reliability & Validity
Step 7: Revisions to test items

Whenever possible the malfunctioning test items should be revised and added to the pools of acceptable test items. When revisions to test items are substantial, they should be returned to step 4.

Step 8: Test assembly

Test booklets are compiled at this step. This step involves three stages.

1. Determine the test length and the number of forms needed and the number of items per objective.
2. Select test items from the available pool of valid test items.
3. Prepare test directions, practice questions, test booklet layout, scoring keys, answer sheets, etc.

Step 9: Using the test in the classroom

The test is then administered in the classroom. Students' responses can be recorded and tabulated in accordance with the scheme of analysis which is mostly in terms of specified domain objectives.

Step 10. Establishing reliability and validity

Since, the data are available from the test, the reliability and validity of the test can be found out using appropriate procedures.

Almost all the steps mentioned above were strictly observed while developing the criterion-referenced tests in the five content areas selected for instruction during experimentation. The blue-print of the five content areas is given in the Table: 3. A copy of the criterion referenced -test (used as a post-test) with scoring key is given in the Appendix: 9.

Reliability and Validity of the CRT in Physics

Two important features of any test is its reliability and validity. Reliability of the test refers to the degree to which a test measures something consistently. The definition of reliability includes an important subtlety. As long as a test
consistently measures something, the test is a reliable test. In other words, a test that consistently measures any entity is reliable, even though this entity is not what the test is supposed to be measuring. Validity of the test refers to the degree to which a test measures what it is supposed to measure. Test reliability is a prerequisite to test validity. The validity of many educational tests is limited by their less than optimal reliability (Oosterhof, 1990).

**TABLE: 3 BLUE-PRINT OF THE CRITERION-REFERENCED TEST IN PHYSICS**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Contents</th>
<th>Knowledge</th>
<th>Understanding</th>
<th>Application</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Laws of Motion</td>
<td>8 (1)</td>
<td>6 (1)</td>
<td>3 (1)</td>
<td>17</td>
</tr>
<tr>
<td>2.</td>
<td>Wave Motion</td>
<td>8 (1)</td>
<td>6 (1)</td>
<td>3 (1)</td>
<td>17</td>
</tr>
<tr>
<td>3.</td>
<td>Elasticity</td>
<td>7 (1)</td>
<td>3 (1)</td>
<td>6 (1)</td>
<td>16</td>
</tr>
<tr>
<td>4.</td>
<td>Semiconductors</td>
<td>6 (1)</td>
<td>7 (1)</td>
<td>2 (1)</td>
<td>15</td>
</tr>
<tr>
<td>5.</td>
<td>Semiconductor Diode</td>
<td>6 (1)</td>
<td>5 (1)</td>
<td>2 (1)</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td><strong>Grand Total</strong></td>
<td><strong>35</strong></td>
<td><strong>27</strong></td>
<td><strong>16</strong></td>
<td><strong>78</strong></td>
</tr>
</tbody>
</table>

Note: The number of items for each component is given in the Table. The numbers given in the brackets indicate the weightage given to each item.

**i. Reliability**

To establish the reliability of the test, the investigator adopted the split-half method. According to this procedure, the test is split into two equivalent halves by pooling the scores of the odd numbered items and even numbered items. The correlation between the two halves can be found out using the "Spearman-Brown Prophecy" formula. The investigator has applied this procedure to establish the reliability of the test by using the score of the post test. The reliability of the whole test (five sub tests) is found to be 0.908 and is significant at 0.01 level. Hence, it is concluded that this criterion-reference test in Physics is highly reliable.
ii. Validity

To establish the validity of the test, the investigator attempted to find out the correlation co-efficient between the achievement scores obtained from this test and the achievement scores of the same set of students in Physics as measured in the school examination by calculating the product moment correlation co-efficient. The value of 'r' is found to be 0.832 and is significant at 0.01 level. Hence, it is concluded that the CRT in Physics possesses high validity.

SELF-REGULATED LEARNING SCALE (SRLS)

Self-regulated learning is characterised as a higher order learning by which process individuals activate and sustain the cognitions, behaviours and affects that are oriented toward attaining one's goals. The assessment of the SRL is a complex process and it requires a powerful instrument which adopts a careful analysis and method. The use of SRL strategies of an individual is partly a covert process (since it involves metacognition) and partly a overt process (since it involves motivational elements). The two commonly used procedures to assess the metacognition and related aspect is self-report and observation of its products. Both have their own merits and limitations. Therefore, it is difficult to assess the SRL by means of observation alone. Also, Zimmerman and Martinez-pons (1986) assessed the students' use of SRL strategies by means of a live structured interview. But it needs more time and expertise to assess each student. It is decided to develop a rating scale to assess the students' use of SRL strategies based on the theoretical framework of the present study.

A rating scale involves qualitative description of a limited number of aspects of a thing or of traits. The statements in a rating scale may be much more specific and may enable the judge to identify more clearly the characteristic to be rated. The rating scale is considered to be effective only when the traits and categories are very carefully defined in behavioural (observable) terms. Even though there are several limitations, the rating scales are used as a powerful tool in educational and psychological research (Best & Khan, 1995).
A Likeret type of scale to measure the students' use of SRL strategies was constructed. In a Likert type of scale, people to whom the scale is administered are directed to indicate the extent to which they endorse each statement. The scale consists of both positive and negative items and the students have to register their response in a five point continuum ranging from "very often" to "never". A numerical value is assigned to each response. Then, the numerical values are summed to produce a total score. Hence, this type of scale is sometime called as summated scale (Anderson, 1988). In this scale the students' total use of SRL strategies have been found out by summing the scores of all the items.

CONSTRUCTION OF SELF-REGULATED LEARNING SCALE

Step 1: Writing the Items

This step involves following stages:

1. Collecting a large set of items relating to the particular construct.
2. Statements should be written in such a way that they state different degrees of acceptance of the object.
3. Statements can be collected from a wide variety of sources like authoritative books dealing with them, research literature, etc. A very large pool of items will be adequate to construct the scale.

It was decided to develop a SRLS based on the theoretical work of Zimmerman and Martinez-pons (1986). They have developed a structured interview to assess the students' use of SRL. Keeping these strategies in mind, the investigator developed the SRLS (paper pencil version). Large number of items related to the 10 kinds of SRL strategies were written by the investigator. Before writing the items, the investigator made a thorough analysis of the previous literature. With the help of psychologists and other practicing teachers, 117 items were generated. A copy of the SRLS developed and used for the pilot study is given in the Appendix: 10.

Step 2: Editing of Items

The collected statements have, to be edited or modified in order to

i) avoid double barreled statements

ii) avoid abstract and complex ideas or terminology
iii) cover all statements expressing all degrees of acceptance (rejection)

iv) cover aspects and dimensions relating to the object.

After generating the items, they were sent to the subject experts viz., psychologists and educationists. The explanation about the development of the tool, the dimensions of the tool and the definition of each dimension has been appended to the tool. After receiving the expert opinion, some of the items were modified. The linguistic content of the items has been checked with the help of the language experts. Then, the items were pooled randomly and thus the tool for pilot study was prepared.

**Step 3: Preliminary Administration and Item analysis**

The initial version of the scale with 117 items was administered to a sample of the population for whom the scale is intended. In order to gather meaningful and reliable data on statements, the tool was administered to a large number of population.

The preliminary pool of items forming the questionnaire with a five point responses given against each statement as shown below was administered to the students.

<table>
<thead>
<tr>
<th>Very often</th>
<th>Often</th>
<th>Sometime</th>
<th>Rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

The scoring for positive and negative items are as shown below:

<table>
<thead>
<tr>
<th>Item/Response</th>
<th>Very often</th>
<th>Often</th>
<th>Sometime</th>
<th>Rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Negative</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Separate answer sheet was used to collect the responses. The items were scored according to the scoring procedure.

After the preliminary administration, the items were divided based on the property of normal probability curve. Since, the normal probability curve is useful to separate a given group into subgroups according to capacity, when the trait is normally distributed (Garrett, 1973). The quartile values were calculated. The sample falling under the first quartile (Q1) of the normal probability curve was taken as the lowest
group whereas the sample falling above the third quartile (Q3) was taken as the highest group. The scores between Q1 and Q3 were neglected. Then t test was computed between the highest and lowest groups. The first 40 items having highest t values were considered for the final scale which measures 10 SRL strategies.

**Step 4: Final Scale**

The final form of the scale was arranged and used to measure the students' use of SRL strategies. The 40 items were split to measure 10 SRL strategies as noted below.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the SRL Strategy</th>
<th>Item Numbers</th>
<th>Total Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Self-evaluation</td>
<td>1 to 4</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Organising &amp; Transforming</td>
<td>5 to 8</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Goal setting &amp; Planning</td>
<td>9 to 12</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Seeking information</td>
<td>13 to 16</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Keeping records &amp; monitoring</td>
<td>17 to 20</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Environmental structuring</td>
<td>21 to 24</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Self-consequences</td>
<td>25 to 28</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>Rehearsing &amp; memorising</td>
<td>29 to 32</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>Seeking social assistance</td>
<td>33 to 36</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Reviewing records</td>
<td>37 to 40</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>40</strong></td>
<td></td>
</tr>
</tbody>
</table>

A copy of the SRLS used for the final study is given in the Appendix: 11. The final scale was administered to the control group and experimental groups as pre-test and post-test. The maximum possible score of the scale is 160 and the minimum score is 0. Each statement is followed by five responses representing five degrees of acceptance.
Reliability and Validity of the SRLS

i. Reliability

To establish the reliability of the SRLS "Split-half Method was adopted. The scale was divided into two halves. The scores for the odd-numbered items and the even numbered items were separated. Each of the two sets of items was treated as a separate test. The two subscales were then correlated and this co-efficient is taken as a measure of reliability. A further step is to correct the correlation co-efficient secured between the two halves by applying the "Spearman Brown Prophecy" formula. The investigator adopted the same procedure taking the answer-scripts from all the three groups. The correlation between the scores of the two halves was determined. The reliability of the whole scale is found to be 0.806 which is significant at 0.01 level. Hence, it is concluded that the SRLS possesses high reliability.

ii. Validity

The investigator has developed the SRLS after a thorough analysis of the review of related literature. In most of the countries the students use of SRL strategies was measured by structured interview and there is no particular tool available to measure the SRL strategies spelt out by Zimmerman and Martinez-Pons (1986) directly. Also, no SRLS was available for the investigator to find out the validity of the developed SRLS. Due to non-availability of time and personnel factor it was not possible for the investigator to develop a parallel form of the tool. Hence, the investigator has decided to establish only the following methods of validity.

The researcher ensured the validity of the tool through systematic planning and constructions. The validation of content through competent judgements is most satisfactory when the sampling of items is wide, judicious and when adequate standardisation groups are utilised (Garret, 1973). While developing the scale, the items were collected after exhaustive analysis of the content followed by consultation with experts in the area of Education and Psychology. As suggested by the experts the modifications were carried out in the content of the items. Hence, it is evident that the scale possesses high "content validity".
A test is said to have face validity when it appears to measure whatever the author had in mind namely, what he thought that the tool was measuring. Judgements of face validity are very useful in helping an author decide whether the scale items are relevant to some specific situation (Garett, 1973). This SRLS was already sent to a number of judges and they expressed their satisfaction about the tool. Hence, it is obvious that the SRLS possesses the face validity.

Further, the validity of the tool was worked out with the help of the intrinsic validity procedure which is the square root proportion of true values (i.e., square root of its reliability). Thus, the worked out intrinsic validity co-efficient of the SRLS is 0.8978 which is significant at 0.01 level. Hence, it is assumed that the tool possesses high intrinsic validity.

PROCEDURE
Experimental Research

Experimental research is one of the most powerful research methodologies the researchers can use. Experimental research is unique in that it is the only type of research that directly attempts to influence a particular variable, and it is the only type that can really test hypotheses about cause and effect relationships. Experimental studies attempt to ensure valid casual inferences from randomised experiments conducted within the practical constraints of available resources and time. Experimental design is one of the most effective designs available for the educational researchers to use in determining cause and effect.

The pure experimental method is not possible in the natural field situation because it requires both perfect matching and random assignment of the subjects of the experimental and control groups for the manipulation of the independent variables. It also involves the human factors which may affect the outcome of the study. Hence, the only experimental method which is appropriate for the present study is quasi-experimental method. Here, the researcher has control over the independent variable to be manipulated (instructional methods) and to find out the effectiveness of the treatment variable on human behaviour (learning). Moreover, the quasi-experimental
design does not require randomization and matching of all the variables which affect the dependent variable. In a quasi-experiment, some or all of the variables are ex-post factor, which means they are not under direct control of the experimenter (Elmes et al. 1981).

**Pre-test, Post-test, Non-equivalent Groups Design**

This design is often used in classroom experiments when experimental and control groups are such naturally assembled groups as intact classes, which may be similar (Best & Khan, 1995). This design do not include the use of random assignment. If a researcher is interested in studying the effect of three different methods in changing the cognitive behaviour in a school subject, the researcher needs three classes of students to work with. Owing to practical difficulties, it was not possible for the researcher to select the students at random from each class to form three groups corresponding to three methods. The researcher, therefore uses each class intact and gives each class a different treatment. The design adopted is as follows.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-test</th>
<th>Method</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt; 0</td>
<td>X1</td>
<td>&gt; 0</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 0</td>
<td>X2</td>
<td>&gt; 0</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 0</td>
<td>X3</td>
<td>&gt; 0</td>
</tr>
</tbody>
</table>

Usually, these groups are naturally assembled sets of students as intact classes. The interpretation of the results will depend largely upon whether the groups differed on some characteristics related to the independent variable. The difference between the means of pre-test and post-test scores of each group is tested for statistical significance (Best & Khan, 1995). Analysis of variables is also used to find out the significant difference among the groups.

**SAMPLING**

The sample of this study consists of 105 students of Std XI (First year Higher Secondary Course) studying in three different schools. The schools are situated in Coimbatore and Harur of Tamilnadu, a southern state of India. The schools were selected on the basis of the computer facilities available in their campus since the packages developed for this study require Windows-95 based computer systems.
One of the three schools was treated as the control group while the other two schools were treated as the experimental groups. The distribution of the sample is given in Table: 4.

**TABLE: 4 DISTRIBUTION OF SAMPLE OF THE STUDY**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the School</th>
<th>Group</th>
<th>No. of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rangammal Kalvi Nilayam, Coimbatore.</td>
<td>Control Group</td>
<td>35</td>
</tr>
<tr>
<td>2.</td>
<td>Mani’s Higher Secondary School, Coimbatore</td>
<td>Experimental Group I</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>Total</strong></td>
<td><strong>105</strong></td>
</tr>
</tbody>
</table>

The whole sample of the study comprise 105 urban students with similar socio-economic status. All of them hail from middle-class families and they are of the same age group. They study in the English medium classes with Mathematics, Physics, Chemistry and Computer Science as optional subjects.

**ADMINISTRATION OF THE PRE-TEST**

A separate pre-test in Physics was developed and used in this study. Since, the experiment was conducted in the middle of the academic year, to control the logistics effect, the investigator decided to develop a separate pre-test for this study. The pre-test assessed the knowledge of the students in Physics at Tenth standard level. Also, the self-regulated learning scale was administered to all the students before the conduct of the experiment.

The identity of the control group and the experimental groups was established by an analysis of variance among the three groups based on the scores of the scholastic achievement in Physics and their use of self-regulated learning strategies as measured by the pre-test. A copy of the pre-test tool with the scoring key is given in Appendix: 8. The scores obtained by the control group and experimental groups in the pre-test is given in the Appendix: 12.
EXPERIMENTATION

This study adopts "Pre-test, Post-test, Non-equivalent Groups Design". As already stated, three identical groups comprising 35 students each (based on pre-test score & scores in SRLS) were formed. One of the groups was treated as control group while the other two groups were treated as experimental groups. Traditional lecture method was adopted in the control group. CAI as individualized instructional strategy was adopted in the experimental group-I. CAI with peer interaction was adopted in the experimental group-II. In the present study three different instructional strategies were adopted to the three different groups.

i) Lecture Method (LM)

The Lecture Method is still one of the successful instructional strategies in Physics teaching even after the availability of the sophisticated media. This method is teacher-centered. But, this method is still useful to explain the equations in Physics and the cause and effect phenomena. It is a flexible method, since the teacher can adopt himself to the subject matter, time limit, available apparatus and equipments in a very short notice. Students' attention and interest are captured by the teacher by his way of presentation, gestures, etc. Apart from all these factors, the physical environment of the classroom itself enhances the sense of security in the minds of the students providing them with group feeling, emotional attainment and social reinforcement which lead to expected levels of interaction and feedback in the Physics class. Hence, the lecture method which is still considered as one of the best and cheapest methods of teaching was adopted by the researcher in the control group.

ii) CAI as Individualized Instructional Strategy

Computers are considered to be one of the most powerful sources in the flow of information. Computer Assisted Instructional packages are helpful for the learners to study the lessons in their own pace. There are individual differences existing among the students and the CAI provides the instruction according to the ability of the individual learner. Instruction and instructional models of CAI geared the individuals to move quickly and this motivates the learners to learn much faster. The CAI as individualised instructional strategy was used as the experimental intervention to the experimental group-I.
iii) CAI with Peer Interaction

Some areas of Physics need imagination on the part of the learners for the better understanding of the concepts learnt. CAI with its acknowledged potentialities may not be sufficient for learners to understand some difficult contents in Physics which need some more explanation. Psychology suggests that an individual will learn more effectively when he receives information from his peer group interaction. Hence, it was decided to adopt the peer group interaction with CAI as another experimental intervention. The experimental group-II in the study involves CAI with peer group interaction.

Instructional Process carried out in Control and Experimental Groups

Five syllabus based computer software packages were developed by the investigator to teach Physics to the students of Std XI. The packages were used as the experimental intervention in this study. The same contents were taught to the control group through lecture method. The instructional process carried out in the control and experimental groups are as follows.

i) The Control Group

Lecture method was adopted to the control group. The investigator himself taught the content using charts. The classes were conducted for a period of 40-45 minutes each. The five topics were taught to the control group. Care was taken to see that better interaction was maintained throughout the period of instruction. Almost all the content areas are equal in length in terms of the scope of the contents. Hence, there was no problem for the investigator to teach them within the period of 45 minutes. Also, the time allotted to teach each of these content areas was 45 minutes as per the norms followed in school syllabus and time table. Post-test in the respective content areas were administered immediately after the completion of the instruction.

ii) Experimental Group-I

This group received instruction individually through the specially developed Computer Assisted Instructional packages in the said content areas. As already instructed the learners learnt the given content areas one by one individually from the computer terminal which had already been loaded with the said packages. Since, the students had
already been exposed to computers, they did not face any problem in using the computers. Some of the students took 25 minutes to master the given content while others took even 55 minutes to do the same. The post-tests were administered to the students as soon as instruction in the respective content areas was over. Care was taken to see that no discussion or consultation occurred among the students throughout the instructional process.

iii) Experimental Group-II

This group received instruction individually through computers and was allowed to discuss with their peer group. For this purpose the investigator arranged for 10 personal computers on hire. The programme was loaded in each computer. The investigator assigned the topic and the students were asked to complete the packages. The students were allowed to discuss with their peers whenever they were in doubt and really needed help. It was observed that some of the students completed the packages within 25 minutes. They began to help their friends in answering the questions as raised in the tutorial package. Students in this group were actively engaged throughout the instructional process. Post-tests were conducted immediately after each of the topics was completed by the students. The investigator presented himself supervising the students throughout the experimentation in order to avoid unwanted discussion and chatting during the instructional process. Further, proper seating arrangements were made while the students were taking the tests. The scores of the control group and the experimental groups in the post-test is given in the Appendix: 13. The students' use of Self-regulated learning strategies were also assessed using SRLS immediately after the fifth post-test was over. The scores of the control group and the experimental groups in SRLS before and experimentation is given in the Appendix: 14.

ADMINISTRATION OF RETENTION TEST

A retention test in the same content area was also administered to all the three groups a month after experimentation. The same test used as post-test was administered here to find out the retention of the students. The scores obtained by the three groups in the retention test is given in the Appendix: 15.
ANALYSIS OF THE DATA

The scores of the student of the three groups were tabulated. Thus, the tabulated data were screened and grouped for the purpose of further analysis. The Mean and SD were computed. The ANOVA was attempted to find out the difference among the control group and experimental groups. The correlational and regressional analyses were also made.

CONCLUSION

The development and validation of computer software packages in Physics, the construction and validation of Self-Regulated Learning Scale and the detailed procedure of the development of CRT in Physics have been clearly discussed in this chapter. Necessary steps taken in experimentation and the instructional process carried out in the control group and experimental groups have also been elucidated here. The analyses and interpretation of the data along with a description of testing of the spelt out hypotheses are presented in the next chapter.