# CHAPTER IV

**METHODOLOGY**

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CHAPTER IV
METHODOLOGY

INTRODUCTION

Research is a scientific and systematic search for pertinent information on a specific topic. It is also referred to a search for knowledge. Advanced Learner’s Dictionary (1952) of Current English says that Research is a "careful investigation or inquiry specially through search for new facts in any branch of knowledge". Redman and Mory (1923) define research as a "systematized effort to gain new knowledge". D. Slesinger and M. Stephenson (1930) in the Encyclopedia of Social Sciences define research as "the manipulation of things, concepts or symbols for the purpose of generalising to extend, correct or verify knowledge, whether that knowledge aids in construction of theory or in the practice of an art".

Research emphasizes the development of generalizations, principles or theories that will be helpful in predicting future occurrences. Research usually goes beyond the specific objects, groups or situations investigated and infers characteristics of a target population from the sample observed. Research is more than information retrieval, the simple gathering of information. Research on the whole demands accurate observations and description. It strives to be objective and logical, applying every possible test to validate the procedures employed, the data collected and the conclusions reached. Research is a continuous process, every time searching in different ways to understand better and more about the truth.

Methodology is defined as "the study of methods by which we gain knowledge, it deals with the cognitive processes imposed on research by the problems arising from the nature of its subject - matter" (Rickman, H.P., 1967). According to Abraham Kaplan, Chandler (1964), Research Methodology is the description, explanation and justification of various methods of conducting research.
In this chapter, an attempt is made to describe the following aspects:

- Development and validation of computer assisted instructional packages in teaching Biology at Std. XI.
- Development of Criterion Referenced Tests (CRT) in the content areas selected for instruction in the experimentation.
- Establishing the reliability and validity of Criterion Referenced Tests and Cattell's 16 P.F. tool.
- Experimental Designs
- The conduct of the experimentation.

DEVELOPMENT OF SYLLABUS BASED COMPUTER-ASSISTED INSTRUCTIONAL SOFTWARE PACKAGES IN BIOLOGY

One of the objectives of the study being development of syllabus based CAI packages in different modes viz. Tutorial, Drill & Practice and Simulation for teaching Biology at Std XI, an attempt was made to realise the same.

The idea of using computers for teaching purposes in subjects like Biology, etc. raised mixed feeling and met with a variety of reactions.

According to Nelson, et al. (1976), "The unique property of the computer as a medium for education is its ability to interact with the student. Books and tape recordings can tell a student what the rules are and what the right solutions are, but they cannot analyse the specific mistake the student has made and react in a manner which leads him not only to correct his mistake, but also to understand the principles behind the correct solution".

Lysaught and Williams (1968) have described the various steps to be followed in developing a learning material as detailed below:

1. Selection of topic
2. Defining the entry behaviour of the learner.
3. Defining the terminal behaviour of the learner
4. Selecting a model or a paradigm
5. Content analysis and sequencing
6. Writing the frames
7. Editing the programme
8. Initial testing of the programme
9. Evaluation and revision

Taking the above suggested steps into consideration, the investigator has developed the CAI packages. The steps involved in the development of software are given in the Figure 4.

**Fig.4 STEPS INVOLVED IN THE DEVELOPMENT OF CAI PACKAGES**
1. Selection of a topic

Though any topic can be selected for the development of CAI software packages, care should be taken to select the topic which when developed, is beneficial to many in many ways. Before selecting the topic, the investigator had an elaborate discussion with Post Graduate Teachers teaching Biology at Higher Secondary Stage and selected the unit 'Cell Division' in Biology to teach the XI standard students through Computer Assisted Instruction. The teaching of cell division is a complex one which needs additional requirements to learn in a simple way.

2. Defining the entry and terminal behaviour

Fry (1963), asserting the importance of previous learning, says, "previous knowledge influences learning events". The previous knowledge is only vaguely related to the new knowledge being required.

Entry behaviour suggests where the pupil is at the beginning of the instructional process. The investigator determined the instructional objectives (see Appendix:1) and planned the instructional process on the basis of the behaviour of the pupils at the beginning stage. The information regarding the entry behaviour was collected by the investigator through pre-test and through the consultations with the Biology Teachers who were teaching the students and who were well aware of the previous experiences, aptitudes, interests, ability and level of attainment in the Biology subject and so on of the Higher Secondary pupils for whom the CAI was to be planned. Terminal behaviour also suggests where the learner will be at the end of the instructional process. The investigator was very thorough and specific with the clarity and attainability of the objectives with which she started the work. A few of the terminal behaviour spelt out by the investigator are as follows:
At the end of this programme, the pupil
- Recalls biological facts, concepts, principles, etc.
- Cites illustrations of principles, concepts, phenomena, etc.
- Compares the cell divisions, terms, facts, etc with the relevant matters
- Identifies the division of cells.
- Illustrates examples and observes the diagrams for each division.

Thus, the programmer who is also the investigator, outlined precisely the behaviour she wanted the pupils to perform at the end of the CAI programme and accordingly specified the kinds of stimulus material in the software development.

3. Task analysis

Entering the lines of programme into a computer is only a small part of a process which mostly takes place away from the machine and begins with a thorough analysis of the task to be carried out. For the investigator, analysing the task means defining the objectives of the package, analysis of contents (see Appendix2), selecting the contents and mode of presentation. In many respects, this preparatory work resembled the conventional tasks to be carried out for any lesson, but computerization made extra demands, and it forced the investigator to be much more careful and systematic. Every single aspect was sorted out and there was an increased need for clarity and coherence as any inconsistency, any question left out unsolved would cause problems at the later stage.

The analysis of the task was made easier as the investigator followed some of the check list questions framed by M.J. Kenning and M. M. Kenning (1984).

- Is the package to be primarily a testing or a teaching package?
- If it is a teaching package, is it to be an independent package or a package for practicing points seen in class?
- Will explanations be provided?
- When will the explanations be provided?
- How many attempts, are the pupil to be allowed?
- In what order are the questions to appear?
- Are different items or successive attempts to be weighed differently?
- Are the responses to be recorded?
- And, last but not the least, how much control over the material is the pupil to have?

Having established a general scheme on the basis of the materials selected and adopting the replies to the preceding questions, the researcher was ready to sort developing a plan for implementing the decisions.

4. Screen Design

The screen design is an important aspect of an educational software development. The effectiveness of the software depends upon the quality of the screen presentation. The following were the steps which the investigator kept in mind while developing the programs. The screen design was integrated into the whole planning process. Due consideration was given to the educational purpose. Computing terms of the users were given due consideration. The ideas were presented one by one in the form of frames. The drawings were simple. The textual materials were divided into small frames and presented on the first half of the screen. Each frame occupied one screen followed by a question on the next screen with four multiple-choice answers. The corresponding graphics were presented at the bottom right side corner of the screen. Each screen was presented with a help menu.

5. Sequencing

The investigator paid great attention to the organisation of the content material in a sequential order with small steps before writing the frames. This sequential order will enable the students to comprehend the ideas in a rapid manner.
6. Drafting the frames in CAI

A frame presents a small unit of information, requires active responses and may be arranged to give immediate reinforcement. For the present study, the investigator prepared programme in Skinner's Linear style and the programme was written in VISUAL BASIC LANGUAGE. The investigator had seen to it that the frames were unambiguous, brief, simple and straight forward. Sequential presentation of frames and flow charts of software development were prepared for each of the different modes of CAI viz. Tutorial, Drill & Practice and Simulation (see Appendix 3).

Presentation of frames

The contents of the unit "Cell Division" were presented in the form of frames. The unit "Cell Division" is divided into three lessons. Each of the three lessons was developed in three different modes of CAI viz., Tutorial, Drill & Practice and Simulation and thus totally nine packages were developed, the details of which are given as follows:

- The contents and the questions for each frame were the same for all the three different modes of CAI.
- Each frame consisted of three to four lines.
- Each frame insisted upon facts, concepts, etc.
- Some of the frames were developed with necessary graphics.
- Each lesson was developed in such a way that the learner cannot move on to the next lesson without completing that particular lesson.

a. Tutorial

In tutorial mode, the frames are presented one by one followed by a question on the next screen, with four multiple choice answers. Provisions are made such that the learner can choose only one option at a time. The responses can be immediately judged and immediate feedback can also be given according to the learner's response. If the response is
wrong, the feedback will be given in the form of clues to try again for the right answer. In this mode, provisions are made such that the learner can read the previous frames once again or move on to the next frame.

b. Drill & Practice

In Drill & Practice, the frames and questions are the same as that of the Tutorial lesson. The responses can be immediately judged. The judged responses will be given immediate feedback as 'try again' or 'move on to the next, etc. No clues are provided for wrong answers. Provisions are made in such a way that the learner, without mastering the frame can not move on to the next frame.

c. Simulation

The frames and questions are the same as in Tutorial and Drill & Practice mode. But in Simulation mode, each frame is simulated with the help of graphics. If the answer is wrong, feedback will be given as clues and also in the form of graphics.

8. Debugging

Debugging is the most commonly used term for the detection and elimination of the errors or bugs in a programme. The investigator paid great attention to pinpoint and rectify the three categories of errors namely typographical errors not affecting the programme, coding (or technical) errors and logic errors.

9. Editing the programme

The investigator had the following objectives in editing the programme:-
- To eliminate the inadequacies and ambiguities of the programme, if any.
- To improve the logical sequence of the frames
- To sharpen and smoothen the programme
- To improve the technical accuracy of the programme.
The investigator made a thorough review of the entire draft through the three phases of editing namely "Technical Accuracy", "Programming Technique Editing" and "Contents Editing", with the help of computer programmers and subject experts.

10. Production of software support materials

The investigator included some support materials to produce the software. They were educational aims and objectives of the program, content of the program, usability of the program in the classroom, identification of the learner's suitable ages, abilities and groupings, the relevance of the material to the program, the equational limitations and procedure to load and run the program. The user guide to handle the instructional software packages is given in Appendix 4.

11. Try-out of the draft

Sample runs were made in nearby Higher Secondary Schools to know the accessibility of the learners' understanding. After editing the first draft of the program, the investigator attempted for the individual try-out on a representative student sampling for whom the program was developed. This individual try-out gave an opportunity to the programmer-cum-investigator to study the reaction of the learner immediately after the completion of the frames. As the frames were to be finalised on the basis of the feedback received from the individual students, the following were observed by the investigator during the try-out of the draft:

i. An effective rapport was established with the students.

ii. The programmer made it clear to the students that the programme was not for testing but merely for helping the programmer to modify the programmes.

For individual try-out, the investigator randomly selected the students of Std XI who studied Biology, on the basis of their general academic achievement. After the individual tryout, some modifications were done in the programme.
Eventhough the packages had been developed with a lot of theoretical consideration and use of computer potentialities, the CAI package had their own limitations. They are:

i. The developed packages require windows - 95 based computer system to run the programmes.

ii. Animation effects were not included in this package.

A few printouts of the syllabus based software packages are given in the Appendix15.

EVALUATION OF THE CAI SOFTWARE PACKAGES

CAI has a positive impact on learning in the field of education. The finalised CAI software underwent the final evaluation by experts comprising computer specialist, subject experts and specialist in programming. The proforma developed by Rangaraj and Balasubramanian (1995) has been used to evaluate the packages in this study.

All the nine computer packages developed by the investigator were evaluated using the said proforma. This process involves 25 experts comprising teachers, computer specialists, software developers, and educational technologists. The evaluation proforma was supplied to the experts with a request to register their opinion in a three point scale. The percentage score of their responses was computed (see Appendix16).

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. Provisions given for the usage of the programme were brief and clear. More than 98% of the respondents were of the opinion that the objectives of the programme were relevant to the students. The design of the learning material was matched to the objectives of the programme; the learning experiences planned were suited to the objectives of the programme with suitable length and time duration; the questions which occurred at appropriate places were clear, the feed back given to students during
presentation was appropriate, the examples provided during the presentations 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.

It was found that more than 95% of the respondents were of the opinion that the content was matched to the students age and interest, the design of the learning material fulfilled the expected criteria of the material and the feedback provided was appropriate to the instructional objectives. Again, it was found that more than 94% of the respondents were of the opinion that the objectives of the programmes were clear; the 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, students ability and computer medium, the examples given during presentation were proper and suited to pupil's previous knowledge and the computer medium was compatible in its role.

It was found that more than 96% 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 learning experiences were intrinsically motivating and the screen design arrests the attention of the pupils. More over, it was found that only negligible number of the respondents were of the opinion that some of the features of the programmes were adoptable.

It is quite impressive to note that, no one was of the opinion that any feature of the programme was not suited. This ensures the quality of the software and its suitability to the teaching of Biology at Std XI. After a thorough validation, all the nine syllabus based instructional packages developed were used in the study. A CD containing the programmes is attached at the end of the thesis.
DEVELOPMENT OF THE PRE-TEST

A separate pre-test in Biology was developed with a view to control the logistic effect. The pre-test assesses the knowledge of the students in Biology at the tenth standard level. The said pre-test consists of multiple choice items which offer four alternative answers of which only one is correct and the rest are incorrect. It consists of 9 knowledge level items, 9 understanding level items and 2 application items. A copy of the pre-test with the answer key is given in the Appendix.

DEVELOPMENT OF CRITERION REFERENCED TEST IN BIOLOGY (CRT)

As many of the hypotheses had to be tested based on the scores of the pupils as measured by the post-test being administered after giving experimental interventions, it was decided to develop the CRTs in the proposed content areas of intervention.

Criterion Referenced Test means that the test performance is linked or related to behavioural referents (Glaser, 1963) and that the test has been designed and constructed on that basis (Jackson, 1970). The test by design must furnish information about a student's ability to carry out certain performance in absolute terms. Cox and Varges (1964) suggest that a major criterion for referencing be that training has resulted in an increase in proficiency.

Criterion Referenced Test tell us about the students' level of proficiency or mastery of some skills. This is accomplished by comparing a student's performance to a standard of mastery called criterion. A test that yields this kind of information is called a Criterion Referenced Test (CRT). The information, it conveys refers to a comparison with a criterion. This type of information helps us to decide whether a student needs more or less work on some skill or a set of skills. A Criterion Referenced Test is most applicable in the area of skill of testing. Criterion referencing is used by (i) generating or selecting a set of objectives, representing the desirable performance outcomes of instruction (ii) Designing or finding items to adequately measure each objective (iii) presenting acceptable performance levels (iv) administering the test to students and (v) evaluating their performance.
Important features of Criterion Referenced Test

- They are based on a set of behavioural or performance objectives for which they are an attempt to measure.
- They are designed to have a high degree of appropriateness by virtue of being based on objectives.
- They represent samples of actual behaviour or performance.
- Performance on them can be interpreted in terms of predetermined scores.

Difference Between a Criterion Referenced Test (CRT) and a Norm Referenced Test (NRT)

The functional difference between a Criterion Referenced Test (CRT) and the Norm Referenced Test (NRT) are as follows:

Norm - referenced test gives summative results, it tells where the individual or group is, while criterion referenced test gives formative results and tells in what areas to prescribe instruction in order to facilitate the achievement of proficiency. Criterion referenced scores are specifically targeted to objectives, while norm - referenced test scores are more global. Norm - referenced test items are written to produce maximal variability in performance across students while criterion referenced items are written to represent the domain of the objectives as the item writer sees it.

In a Criterion - Referenced Test (CRT), it is necessary to attempt to determine the relation between performance on the test and criterion behaviour. To be justified in considering a test to be criterion - referenced, we might go through steps such as the following in its construction and referencing. The steps involved in the development of CRTs are shown in the Figure 5.
Fig. 5. STEPS INVOLVED IN THE CONSTRUCTION OF CRITERION REFERENCED TEST (CRT)

Steps Involved in Construction of Criterion Referenced Test (CRT)

Step 1: Preparation of content outline

The first step in development of CRT is a decision taken to prepare a content outline listing the skills and knowledge. Depending upon the need, one or more instructional contents, may be taken up for construction of criterion referenced test.

a. Identification of segments

The areas and topics are to be examined and segregated into various segments for which testing was done. Later on they are developed as a unit test following completion of a unit, or it may cover a week of instruction, half a year, a year or any other segment. The test should be based on the chosen segment which is to accurately reflect achievement in that segment.
b. Specification of concepts

The concepts, ideas, or skills covered in the segment are to be specified. The areas in the segment in which learning has taken place are to be decided. The concepts, ideas or skills to be learned are to be stated in any form that has meaning. It is to be stated entirely prior to the instruction.

c. Restating of concepts

The concepts, ideas, or skills in behavioural terms are to be restated. The test ultimately measures the performance that reflect the concepts, ideas and skills. The preparation of test items is facilitated by the availability of objectives stated in behavioural or measurable terms.

Step II: Description of Domain

Segments are to be developed into well defined separate domains. Each of such separate domain is to be verified and analysed for the study of following facts i.e., concepts, principles, process, etc. Later on they to be arranged as per the increase complexity. Description of domain is very important as it provides the basis for item writing. It clearly states the nature and scope of the content specification in sequential, hierarchical or developmental order.

Step III: Identification of measurable objectives

We have to identify the performances of which the test taker should be capable of assuming that he/she has acquired proficiency in the skills and knowledge measured by the test. Hence, the performance of students will be clearly interpretable in terms of intended learning outcomes.

We have to identify the domain that each objective defines; writing items according to the specifications of that domain and randomly selecting at least two per objective to make up the test.
Step IV: Validation of Facts

Validating the facts, skills and knowledge measured by the test are in fact the prerequisite to the performance objectives identified in step 2. This is perhaps the most variable aspect of the process since the validation begins with the application of one's own judgement and extends to include the judgement of a group of experts or actual data obtained by giving the test to a group that demonstrated proficient performance to see whether they possess the skills and knowledge of the test.

Step V: External Review of Steps

The tasks examined should be reviewed by those who are not involved in identifying the domain and its descriptions in terms of content elements and the specific objectives. However, a teacher who teaches biology also to be involved in this task so that she may be able to clarify doubts, if any raised by the external reviewer. The main aim of this review is to sharpen domain description and the specific objectives in order to make them more realistic and functional.

Step VI: Internal Review of Steps

We have to examine all specific objectives along with one or more sample items which accompany each specific objective. The focus of this review is on sharpening further the specific objectives if necessary.

Step VII: Administration of trial run

The test to be administered needs to be tried out on a limited number of students, to get a fix on the instruction. This is possible only if the member who is conversant with the development of the test is associated for trial run.

Step VIII: Modification of Test Items

Whenever needed the malfunctioning of questions should be added to the pools of test questions.
Step IX: Determination of Test in the Classroom

The test is then administered in the classroom. Students' responses can be recorded and tabulated in accordance with the analysis which are mostly in terms of specified domain objectives. The domains being tested are arranged according to the needs of the teachers and administered one after the other in the sequential order. Students responses recorded can be tabulated in accordance with the scheme of analysis which are mostly in terms of specified domain instructional objectives.

Step X: Establishing Reliability and Validity

The reliability and validity of the test can be found out using the available data on the test using appropriate procedures.

All the above said principles were strictly absorbed in the development of the Criterion Referenced Test in the study. A copy of the CRT is given in the Appendix: 8. The blue print of the test is given in the Table1.

### TABLE 1: BLUE PRINT OF THE CRITERION-REFERENCED TEST IN BIOLOGY

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Contents</th>
<th>Cognitive Level</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Knowledge</td>
<td>Understanding</td>
</tr>
<tr>
<td>1.</td>
<td>Mitosis</td>
<td>15 (1)</td>
<td>19(1)</td>
</tr>
<tr>
<td>2.</td>
<td>Meiosis-I</td>
<td>14(1)</td>
<td>17(1)</td>
</tr>
<tr>
<td>3.</td>
<td>Meiosis-II</td>
<td>7(1)</td>
<td>9(1)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>36</td>
<td>45</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.
THE RELIABILITY AND VALIDITY OF THE CRITERION REFERENCED TEST IN BIOLOGY

To establish the reliability of the test, the investigator adopted the split-half method. The test is split into two equivalent halves by pooling the odd numbered items for one score and the even numbered items for another score. This usually makes the two scores obtained from a single test reasonably equivalent. In this way two scores for each pupil are obtained, one on odd numbered items and the second on the even numbered items. The correlation between the results of the two halves is determined and from these, the reliability of the whole test is calculated by applying the 'Spearman-Brown Prophecy' formula.

The investigator adopted the same procedure for establishing the reliability of the test by using the scores of the post test. The reliability of the whole test is found to be 0.89 and is significant at 0.01 level. Hence, it is concluded that this CRT in Biology is highly reliable.

Validity of the Test

To establish the validity of the test, the investigator attempted, to find out the correlation co-efficient between the achievement score in Biology obtained from this test and the scores of the pupils in Biology as measured in Biology in the School examination by Product Moment Correlation Co-efficient Method. The value of ‘r’ is found to be 0.887 and is significant at 0.01 level. Hence, it is concluded that the test has high validity.

ASSESSMENT OF LEARNERS' PERSONALITY

As the relative effectiveness among different modes of CAI packages has to be studied in relation to learners' personality traits, there is need for assessing the personality of the samples.

Personality is 'The dynamic organisation within the individual of those-psychological systems which determine his unique adjustment to the environment.'
To assess the personality factors of the learners, the investigator used the 16 Personality Factor Questionnaire (16 P.F) Form D developed by Cattell, R.B. A copy of the 16 Personality Factor Questionnaire Form D along with the response sheet is given in Appendix 9. The 16 Personality Factor Questionnaire is an objectively storable test devised by basic research in psychology to give the most complete coverage of personality possible in brief. The test was designed for use with individuals aged sixteen and above. Form D of the questionnaire is most appropriate for literate individuals. The test can be scored by hand or by machines.

The personality factors measured by the 16 P.F are not just unique to the test but instead rest within the content of a general theory of personality. Thus, its dimensions or scales are essentially independent. Any item in the test contributes to the score on one and only factor so that no dependencies were introduced at the level of scale construction. In addition to the 16 primary factors, the test can be used as a measure of eight secondary dimensions which are broader traits scorable from the component primary factors.

Arrangements of Questions

Ten to thirteen items are provided for each scale in form D. The questions were arranged in a roughly cyclic order determined by a plan to give maximum convenience in scoring by stencil and to ensure variety and interest for the examinee. Three alternative answers were provided for each of the questions and the respondent should choose one among them.

Instruction for Administration

General: Simple and clear instructions were printed for the examinee on the cover page of the test booklet. Although the test can be virtually self-administering, it is always important to establish good 'rapport' with the examinees, whether tested individually or in groups.
Detailed Instruction

Answers are always made on a separate answer sheet never on the reusable booklet. The investigator has to inform the respondents to use a separate answer sheet which is to be provided. She has to ask the respondent to enter his name etc. at the top of the answer sheet and then to read the instruction on the cover of the test booklet to himself and then to work the four examples. The test is untimed, but it is good to remind examinees that they should not delay but should give immediate answers and move along. Educated readers usually take 45 to 60 minutes per form. Care must be taken to ensure that only one answer is given for each question on the test.

Principles and Mechanics of Scoring

Each answer scores 0, 1, or 2 points except the factor B answers which score 0 (incorrect) or 1 (correct). The score of each item contributes to only one factor total. Tests can be either hand scored, with a stencil key or machine scored. Hand scoring is accomplished by key easily, rapidly and in a standard manner.

Converting Raw Scores into Sten Scores

The meaning of raw scores from any form or combination of forms of the 16 P.F. depends upon the particular forms used. Consequently, before these raw scores can be evaluated and interpreted, they must be converted into a sten which places the examinees' score in relation to scores obtained by other people in some defined population.

The standardisation table converts raw scores to stens, a practice consistent with best modern usage, aiming at a good, but not unrealistically refined degree of accuracy in expression of results.

Sten scores are distributed over ten equal interval standard score points from 1 through 10, with the population average fixed at sten 5.5. The available selection of norm tables permits the conversion of any given raw score for any of the 16 personality factors to stens.
The tables cover the general adult population and various sub-samples, with various tables for individual forms and scoring and use of the Norm Table. Once the tests have been administered there remains the task of obtaining raw scores to interpretable standard sten score.

**Procedures for Calculating Second-Order Factor Scores**

It has been indicated that the 16 PF can be scored for broad second order factors as well as for the sixteen primaries. Eight second order factors have been identified and replicated at the present time. The first four, which will generally be of most interest to practitioners are,

- QI Introversion Vs Extroversion
- QII Low Anxiety Vs High Anxiety
- QIII Tender-minded Vs Tough Poise
- QIV Subduedness Vs Independence.

The description of the four second order personality factors is enclosed in the Appendix 10.

Second-order scores are more easily derived from the sten scores on the primaries than from raw scores. A separate table was used for Girls and Boys for calculating the second order factors.

Second-order scores can be obtained from Tables separately given for males and females by following certain steps as detailed below:

1. In the column at the far left of the form, place the sten score for each factor in the appropriate box.
2. From the dotted line from Factor A sten score until a circled number is reached. Multiply the factor A sten score by the circled number. Enter the result in the box immediately following the circled number. Continue following the line until another circled number is encountered. Repeat the same procedure as before. Continue until all boxes in the Factor A row are filled.
3. Repeat the procedure in step 2 for Factor B and all other Factors.

4. Add each vertical column on the page and place the sum of each column in the appropriate box below.

5. In each pair of vertical columns, the sum of the second column (the shaded column) is subtracted from the sum of the first column. Place the answer in the box beneath the subtraction. The decimal point for the score has already been correctly placed on the form. The scores obtained from this procedure are the sten scores of the second-order factors indicated.

The 16 P.F. inventory was administered to all the subjects of control and experimental groups. The responses made by the subjects to the Cattell's 16 P.F. Inventory were scored, tabulated and analysed. The second order factor scores viz. Extroversion, Anxiety, Tough Poise and Independence were also computed as detailed above. The scores of the subject of the control and experimental groups for the 16 primary personality factors (sten scores) as well as the second order factor scores viz. Extroversion, Anxiety, Tough Poise and Independence are given in the Appendix 11.

Reliability and Validity of the 16 P.F. Questionnaire

Reliability

The consistencies of the 16 P.F. scales that is the agreement of the factor score with itself under some change of conditions are given in all relevant ways in the manual. The first type of consistency to consider is reliability or the agreement of the factor score over time. Reliability may be further sub-divided into (a) dependability, i.e., short-term test-retest correlations and (b) stability, that is retest after a longer interval.

The investigator re-administered the same test to the 10% of the same students sample after one month of the first administration of the test. A correlation coefficient was carried out between the two sets of scores and results were given in Table 2.
TABLE 2. RELIABILITY ESTIMATIONS OF THE 16 PERSONALITY FACTORS QUESTIONNAIRE

<table>
<thead>
<tr>
<th>Factors</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-efficient</td>
<td>90</td>
<td>58</td>
<td>58</td>
<td>60</td>
<td>82</td>
<td>60</td>
<td>94</td>
<td>77</td>
<td>73</td>
<td>61</td>
<td>64</td>
<td>57</td>
<td>78</td>
<td>88</td>
<td>59</td>
<td>62</td>
</tr>
</tbody>
</table>

Decimal points are omitted. All are significant at 0.05 level.

From the table, it is found that the tool is highly reliable.

From the Table 2, it is found that the tool is highly reliable.

Validity

The items in these final forms are the survivors from several thousands of items originally tried and constitute only those which continue to have significant validity against the factors after ten successful factor analysis (Cattell, 1973) on different samples. These analysis have both verified the existence and natural structure of the sixteen factors, and cross validated the test items in their correlation with the factors on different adult population samples.

PROCEDURE

Experimental Research

Experimental Research is a scientific method. It is oriented to the future in the sense that the researcher is seeking to evaluate something new. It is a process of contribution to the already acquired fund of knowledge. According to John W. Best (1995) "Experimental research is the description and analysis of what will be, or what will occur, under carefully controlled condition."

The purpose of experimentation is to identify functional relationships among phenomena through staging the occurrence of certain outcomes under controlled conditions designed to prevent the confusing effects of the operation of extraneous factors. Experimentation can be considered a technique of deliberately staging a situation designed to force nature to provide a 'yes' or 'no' answer to a specific hypothesis concerning the phenomena under discussion.
Experimental design is the blueprint of the procedures that enable the researcher to test hypotheses by reaching valid conclusions about the relationship among the variables. Section of a particular design is based upon the purposes of the experiment, types of variables to be manipulated and conditions or limiting factors under which it is conducted.

The pure experimental method is not possible in the classroom situation. It requires both perfect matching and random assignment of the subjects of the experimental and control groups for the manipulation of independent variables. The only experimental method which is adequate for this study is quasi-experimental method. The investigator has control over the independent variable to be manipulated (instructional methods) to find out whether the effectiveness of the treatment variable is influenced by the personality of the learners. The quasi-experimental design does not require randomization and matching of all the variables which affect the dependent variable.

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

True experimental design provides the strongest, most convincing arguments of casual effect of the independent variable because they control for most sources of internal validity. There are, however, many circumstances in educational research for which, while casual inference is desired, it is unfeasible to design true experiments, or in which the need for strong external validity is greater. The most common reason that experimental designs cannot be employed are that randomization of subjects to experimental and control groups is impossible and that a control or comparison group is unavailable, inconvenient, or too expensive. Fortunately, there are a number of good designs that can be used under either of these circumstances.

Quasi Experimental design is often used in classroom experiments in which the experimental and control groups are such naturally assembled groups as intact classes. They may be similar in all respects.
If a researcher is interested in studying the effect of four different methods in changing the cognitive behaviour in a school subject, it may not be possible to assign students randomly to each class. It is better to take intact classes for such experiments and establishing the homogeneity among these groups with respect to very important dependent variables by applying analysis of variance. The design adopted in the study is given as follows:

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pretest</th>
<th>Method</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt; 0</td>
<td>&gt; $x_1$</td>
<td>&gt; 0</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 0</td>
<td>&gt; $x_2$</td>
<td>&gt; 0</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 0</td>
<td>&gt; $x_3$</td>
<td>&gt; 0</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 0</td>
<td>&gt; $x_4$</td>
<td>&gt; 0</td>
</tr>
</tbody>
</table>

Usually, these groups are naturally assembled sets of students. The interpretation of the results will depend largely upon whether the groups' achievement differ with each other. Analysis of variance was also used to find out the homogeneity among the groups with respect to learners' entry behaviour in Biology as measured by the pre-test.

**SAMPLING**

**Sample of the study**

The samples for the study were selected from four different Higher Secondary Schools studying at Std XI. The schools are situated in the city of Coimbatore. The sample consists of 167 students of Std XI studying 'Biology' as one of the optional subjects. The schools were selected on the basis of the computer facilities available. The distribution of the samples for the control and the experimental groups is given in Table 3.
TABLE 3. THE DISTRIBUTION OF SAMPLES FOR CONTROL AND THE EXPERIMENTAL GROUPS

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the School</th>
<th>Group</th>
<th>No. of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male</td>
</tr>
<tr>
<td>1.</td>
<td>Mani’s Higher Secondary School, Coimbatore</td>
<td>Control Group</td>
<td>30</td>
</tr>
<tr>
<td>2.</td>
<td>Suburban Higher Secondary School, Coimbatore</td>
<td>Experimental Group - I</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All the above samples were of the same age group with both method was adopted in the control group while Computer-Assisted Instructional strategy in different modes viz. Tutorial, Drill & Practice and Simulation were adopted as experimental treatments in the experimental groups I, II and III respectively.

ADMINISTRATION OF THE PRE-TEST

In order to establish the identity among the control and experimental group with respect to pupils' scholastic achievement in Biology, the pre-test was administered to all the four groups. The scores obtained by the pupils of the control and experimental groups in the pre-test are given in the Appendix 12.

EXPERIMENTATION

Pre-test, Post-test, Non-equivalent Groups Design was adopted in this study. As already stated, four groups each of 49, 36, 36 and 46 respectively of XI standard students studying in four different schools were formed by taking intact classes. One of the groups was formed as the control group (group with 49 samples). Traditional Lecture method was adopted in the control group. CAI modes (ie. Tutorial, Drill & Practice, and Simulation) as individualised instructional strategy was adopted in the Experimental groups. Tutorial method was adopted in the Experimental Group I (group with 36 samples).
Drill & Practice was adopted in the Experimental group II (group with 36 samples). Simulation method was adopted in the Experimental Group III (group with the samples size of 46). The above mentioned instructional strategies are explained as follows.

**Lecture Method**

Lecture Method is the most commonly used method of teaching even after the availability of the sophisticated media in this technological world. Lecture method is a teacher controlled and information centered and in this method the teacher works as a sole resource in classroom instructions. In addition, the students can be provided with readymade knowledge. It is quite an economical method and the students gain knowledge and have an interactivity with others. Using this method, the knowledge can be imparted to the students quickly. It is quite easy to impart, factual information and historical anecdotes in this method. It minimises the chances of any gaps or overlapping. Lectures may motivate, instigate, inspire a student for some creative thinking. Lecture method is considered to be one of the best methods adopted in teaching.

**CAI Mode No.1: Tutorial**

This mode attempts to put the computer into the role of a teacher instructing an individual learner. Tutorial mode is also an instructional strategy involved in CAI. The tutorial module selects from its repertoire of teaching operations to suit the circumstances. The two factors to be considered in a tutorial are pedagogics and didactics. Pedagogic factors involve the overall teaching approach. Didactics involve the making of decision as to what and when to teach the subject matter and not reteaching the same point without having given the student a chance to absorb the new material and not repeating the same topic by mistake. Tutorials are useful in learning the concepts. Tutorials provide links to prior learning and it also involves ample opportunities for the learners to develop connective networks through examples and questions. Hence, in the experimental group-I, tutorial method was used as the experimental intervention.
CAI Mode No.2: Drill & Practice

Drill & Practice is one of the important modes of CAI. This mode is involved in utilizing software and the micro-computer. There are selected facts, concepts and generalization that students need to review in science. Vital subject matters only should be emphasized within the frame-work of drill and practice. Computerized drill exercises allow the students to move at their own pace and with immediate feedback. Drill & Practice are efficient skill builders. These programs afford additional review in a highly motivational and interactive format. It has its own advantage over the learners, since it masters the skill thoroughly. To increase retention of worth while content, learners need ample opportunities to review that which has been acquired previously. This CAI mode provides the instruction according to the ability of the learner. This CAI mode was used as the experimental intervention to the experimental group-II.

CAI Mode No.3: Simulation

Simulation experiences are significant in the Science Curriculum. Computerized Simulations are models or imitations of processes. Simulations present life like situations that allow the learners to learn through experiences. Simulation expands and enhances classroom experiences. Attempts are made for the learners to have real experience in a simulated form. No threatening experiences make it so that pupils can freely engage in choosing and deciding the learning. This method is not meant to replace actual hands-on experience. It is used as extension of other classroom activity. A well designed simulation demands more than literal comprehension (Cacha, 1985). They challenge students to use critical thinking and problem-solving skills. Simulation used properly helps the students gain a better understanding of the ideas. Hence, in the experimental group-III Simulation method was used as the experimental intervention.
INSTRUCTIONAL PROCESS CARRIED OUT IN CONTROL AND EXPERIMENTAL GROUPS

Nine syllabus based computer software packages were developed by the investigator; three in Tutorial mode, three in Drill & Practice mode and other three in Simulation mode. The packages were developed for the content area viz. "Cell Division" prescribed in the Biology syllabus for the Std XI. The unit "Cell Division" was divided into three instructional units (i) Mitosis (ii) Meiosis-I (iii) Meiosis-II. The nine modules were used as experimental interventions in this study. The same contents were taught to the control and to the experimental groups. The instructional process carried out in the control and experimental groups are described as follows:

(i) The Control Group

Instruction was given to the control group through the lecture method. The investigator himself taught the content matter using the blackboard, charts and models. The classes were conducted in such a way that the learners interacted with the teacher. The learners were kept active by asking frequent questions from the subject matter. The classes were conducted for a period of 45 minutes each. Almost all the content areas were of equal length. There was no problem for the investigator to teach the learners within the period of 45 minutes. Post-tests in the respective content areas were administered immediately after the instruction was over in the content concerned.

(ii) Experimental Group I

This group received instruction individually through the CAI mode viz. Tutorial. For this purpose, the investigator utilized the computer available in the computer lab. The tutorial packages were loaded in each computer. The students were allowed to sit individually at each computer and the topics were assigned. All the students were allowed to learn individually to the assigned topic. Since the learners have already learnt about computer in their lower classes, they used the computer without any anxiety.
Those who needed help in the operation of computers were given the same by the teacher. Care was taken by the investigator, so that the learners were not allowed to discuss with each other. Some of the learners completed the lesson within 40 minutes and some took even up to 50 minutes. Likewise, the three lessons were taught in consecutive days. After completing each package, the post-test in the respective content area was administered to the subjects in the form of paper and pencil test.

(iii) Experimental Group II

Individualized instruction was carried out in this group also. This group received instruction through a CAI mode viz. Drill & Practice. For this purpose, the investigator arranged some fifteen terminals with windows '95 environment. The investigator loaded the program and assigned the lesson. The students were allowed to sit individually at each computer. The investigator took careful vigil over the learners, such that there were no interaction among the subjects. It was easy for the learners to work individually because they have been already exposed to work with the computers from their lower classes. Those who needed help in the operation of the computer were given the same by the teacher. Some of the learners completed their program within 45 minutes and some of them took between 45-55 minutes. Likewise, the three lessons were taught in consecutive days. The post-tests were administered in the form of paper and pencil test immediately after each lesson was over.

(iv) Experimental Group III

This group received instruction individually through the CAI mode viz. Simulation. For this purpose, the investigator arranged some ten terminals with windows '95. The simulation programmes were loaded in the computers. The students were allowed to learn the packages individually. Care was taken so that there was no interaction among the learners. Since all the learners were exposed to use the computers from their primary
classes, there was no problem for them in handling the computers. However, those who needed help in computer operation were given the same by the teacher. The learners took 45 to 50 minutes to complete each lesson. Likewise the three lessons were taught in three consecutive days. The post-tests were administered in each of the content areas in the form of paper and pencil test immediately after the instruction was over.

Administration of Post-Test

As already stated the post-test were administered to all the four groups immediately after the instruction in the respective CAI mode was over. Post-tests were of multiple choice items. It offered four alternative answers of which only one is correct and the rest are incorrect. The questions were selected from the contents instructed to the students of control and experimental groups. For each correct answer, the score is 'one' and for a wrong answer there is no score. Multiple choice type of items were selected because it is unquestionably easier to score and easier to analyse in terms of patterns of incorrect responses. Multiple choice items were unique among objective type tests because they are easy to measure the higher levels in the taxonomy of educational objectives. The scores obtained by the pupils of the control and experimental groups in the post-tests are given in the Appendix13.

ADMINISTRATION OF RETENTION TEST

A retention test in the same content area was also administered to all the four groups a month after experimentation. The same test used as post-test was used as the retention test to find out the retention of the students. The scores obtained by the pupils of the control group and experimental groups in the retention test are also given in the Appendix14.
ANALYSIS OF DATA

The scores of the students of the four groups as measured by the various tools were tabulated and analysed using appropriate statistical techniques. The formulated hypotheses were also tested using appropriate statistical techniques.

CONCLUSION

The development and validation of computer software packages in Biology and the construction and validation of CRT in Biology have been clearly discussed in this chapter. The experimental design and the instructional process carried out in the control group and experimental groups have also been elucidated here. The analysis and interpretation of data along with a description of testing of the spelt out hypotheses are presented in the next chapter.