CHAPTER-III

DESIGN AND
PROCEDURE OF
THE STUDY
3.1.0 INTRODUCTION:

The present study is experimental in nature. Experimental study is that which tests causal relationship by observing the behaviour of the subject under conditions where some variables are controlled and others manipulated.

The term experiment should be confined to those actions or series of actions where it is possible to do all of the following:

- Randomly assign the subjects of the experiment to either an experimental group (to which something is done) or a control group (to which the thing done to experimental group is not done).
- Manipulate (do something to) the experimental group.
- Technically a true experiment must be distinguished by characteristics of ‘random assignment’, ‘manipulation’ and ‘control’.

By definition, experimental research is always quantitative.

3.2.0 RESEARCH DESIGN

Research design is a mapping strategy which is based on sampling technique. It essentially includes objectives, sampling research strategy, tools and techniques for collecting the evidences, analysis of the data and reporting the findings. A researcher designs the work before getting the project underway.

An experimental design is a blue print of the procedure that enables the researcher to test the hypothesis by reaching valid conclusions about relationship between independent and dependent variables. It refers to conceptual framework within which the experiment is conducted. In the present study the investigator has employed
Two Group, Randomized Matched Subjects, Post-test-only Design. In this design instead of using random assignment of subjects to experimental and control groups, a technique of matching is used. The variable selected for matching i.e. intelligence, has a significant correlation with the dependent variable i.e. post-test achievement scores. The subject from desired population was paired so that their scores on matching variable became as close as possible. One subject of each pair was randomly assigned to one group and the other to the second group. A coin was tossed to designate the groups as experimental and control group.

Fig. 3.1: Experimental research design: Two Groups, Randomized Matched Subjects, Post-test-Only Design.

<table>
<thead>
<tr>
<th>Randomly assigned as</th>
<th>CAI treatment</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Randomly assigned as</th>
<th>Traditional teaching</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This diagram can be tabulated as:

**Table 3.1: Experimental Research Design**

<table>
<thead>
<tr>
<th>Scientific random assignment of subjects to-</th>
<th>Independent Variable</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td>Computer Aided Instruction</td>
<td>Experimental group’s mean achievement score</td>
</tr>
<tr>
<td>Control group</td>
<td>Traditional Teaching</td>
<td>Control group’s mean achievement score</td>
</tr>
</tbody>
</table>

The mean achievement score of both the groups were computed to test the significance of the observed difference between them.
3.2.1 Rationale for post test only design on matched groups:

Reasons for employing Post Test only- Control Group Design on matched groups in the present experiment were as below:

1. Campbell and Stanly (1969)\(^9\) recommended post test only control group design for experiments with teaching methods for the entirely new subject matter. They argue pretests in such settings are impossible or inappropriate. In the present experiment subject matter to be taught to the experimental and the control groups was entirely new. It was neither grounded in the science curricula of previous classes nor in continuation with the text material read in the previous classes. Therefore, pretest in this situation was not considered appropriate and pretest posttest control group design was not employed. Campbell and Stanley (1969) are of the opinion that posttest only control group design is appropriate to all of the settings where pretest posttest control group design or Solomon four group design might be used.

2. Randomization does not ensure equality for small groups. Group size in the present study was initially decided to be twenty five students. A group of less than thirty students is considered a small group. Therefore, paired matching was considered necessary to ensure equality of groups on mediating variable having a strong effect on student learning i.e. intellectual capacity of the students. Pairing was possible in three ways:

   - On the basis of previous knowledge.
   - On the basis of intellectual capacity.
   - On the basis of both the previous knowledge and intellectual capacity.

Previous knowledge reflecting the standing of the student with respect to the subject was not relevant to the text material to be taught during the experiment. As the concepts to be taught during treatment had no foundation in the previous learning of the students, the impact of previous knowledge was not considered as a significant contributor towards student learning. Intellectual capacity of the student is a major

contributor towards student learning. It would be a strong mediating factor if not controlled. Therefore, both experimental and controlled groups were matched on intellectual capacity. Matching of groups on two traits requires a large initial sample (Fraenkel and Wallen, 1993). As a large sample was not available, it was not possible to match the groups on two traits i.e. previous knowledge and intellectual capacity.

3.3.0 VARIABLES

In this experimental research, following variables have been studied.

3.3.1 Independent variables:

The independent variables are the conditions or characteristics that the experimenter manipulates or controls in the attempt to ascertain their relationship to the observed phenomenon. The independent variable is a manipulated variable in an experimental study whose presence or degree determines the change in the dependent variable. The independent variables that were used in the present study are computer aided instruction and traditional teaching. These variables were manipulated to study the effect on achievement. The experimental group was given CAI treatment and control group was taught through traditional teaching.

3.3.2 Dependent variables:

The dependent variables are the conditions or characteristics that appear, disappear, or change as the experimenter introduces, removes or changes independent variables. Dependent variable is the observed variable in an experiment or study whose changes are determined by the presence or degree of one or more independent variables. The dependent variable or the criterion variable that was used in the study is achievement in Biology.

3.3.3 Intervening variable:

In many researches the relationship between the independent and dependent variable is not a stimulus to response.

An intervening variable is a hypothetical internal state that is used to explain relationship between observed variables, such as independent and dependent variables. The intervening variables considered in this study were- nature of school, grade level, subject content and intelligence level.

3.3.4 Control variables:

Control variables are extraneous variables that an investigator did not wish to examine in the study. Thus the investigator controls these variables also called covariates. The control variables taken in the present study were- nature of school, grade level, subject content and intelligence level. Control employed for each of this was as follows:

- Nature of school- Only C.B.S.E schools were involved for sampling.
- Grade level- XII class was selected for the present study and it was kept constant during the study.
- Subject content- Both the groups were taught the same unit i.e. ‘Genetics’ of Biology subject.
- Intelligence level- Controlled statistically by Matched randomization
Table 3.2: Independent, Dependent, Intervening Variables and Control employed

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Dependent variable</th>
<th>Intervening variable</th>
<th>Control employed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Computer Assisted Instruction</td>
<td>Achievement in Biology (Genetics)</td>
<td>1. Nature of school</td>
<td>Only C.B.S.E schools were involved for sampling</td>
</tr>
<tr>
<td>2. Traditional teaching</td>
<td></td>
<td>2. Grade level</td>
<td>XII class was selected for the present study</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Subject content</td>
<td>Both the groups were taught the same unit i.e. ‘Genetics’ of Biology subject</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Intelligence level</td>
<td>Controlled statistically by Matched randomization</td>
</tr>
</tbody>
</table>

3.4.0 SAMPLE

Small representative portion of the population is called sample. Sample was collected from XII class students from following two schools using purposive sampling technique. Then matched randomization technique was used on the bases of intelligence of the students to select the final sample for experimental and control group.

The present study was consisted of a sample of 50 students studying in XII class of-

- Hindu Vidyapeeth, Sonepat
- Shiva Shiksha Sadan Sr. Sec School, Sonepat
3.5.0 TOOLS USED

In the present study following tools were used for the collection of data:

- Computer Assisted Instruction module on ‘Genetics’. (Developed by investigator)
- Performa for Assessment of Genetics CAI Module by experts (Developed by the investigator)
- G.C. Ahuja Group Test of Intelligence (GGTI) by Dr. G.C. Ahuja
- Achievement test of ‘Genetics’ (Developed by investigator)
- Retention test (Achievement test of ‘Genetics’ was reused as Retention test)
- Reaction Towards Computer Assisted Instruction Scale for students of experimental group (Developed by investigator)

3.6.0 COMPUTER ASSISTED INSTRUCTION MODULE ON ‘GENETICS’

“A module is a unit of curricular material, complete in itself, further units may be added for achievement of larger or more long term goals”-International Encyclopedia of Education.

According to Purushothaman (1991) an educational module should have four fundamental criteria. It must-

- present or define a set of learning situations.
- have its own carefully specified function and be directed at clearly defined objectives.
- include tests designed to guide the learner or the teacher and provide them feedback.
- be capable of fitting into a variety of learning paths, methods and situations.

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In general, an instructional module refers to the process of learning in which learner learns on his own according to his age, aptitude and abilities. A module is self contained, self pacing and self learning.

Developmental process of the CAI module consisted of two different phases i.e. Pre-development phase and Developmental phase. Each of these phase consisted of different stages that were organized sequentially.

3.6.1 Pre- development phase

Different stages of this phase were:

- Content analysis of XII class syllabus
- Instructional design

Content analysis of class XII syllabus-

Investigator analysed the content of class XII biology syllabus and selected unit- 'Genetics' as content to be taught. The following points were taken care of while selecting the topic for CAI module-

i. The topic should be of the researcher’s own field of study. The researcher should have mastery over the topic.

ii. The length of the topic should be enough to realize the desired objectives.

Rationale for selection of ‘genetics’ as content to be taught:

As CAI module covering the topic of secondary level ‘Genetics’ was not available, Computer Assisted Instruction program to be used in the experiment was developed by the researcher. Tutorial form of presentation was adopted in CAI module.
Rationale for adoption of tutorial form of CAI was:

a) Tutorial form of CAI is almost parallel to the traditional method of instruction with respect to its mode of presentation. The traditional method of instruction by teachers in the schools comprises of presentation of information based on the textbook material with some explanation of terms and concepts and questioning students to assess their learning. Tutorial form of CAI also presents information followed by questions along with feedback to the responses of the students.

b) Techniques of programmed instruction can be classified into three categories i.e., Linear, Branching and Auto-Elucidative (O’Day, Kulhavy, Anderson & Malczynski, 1972). Auto-Elucidative technique of programmed instruction formerly known as adjunct programming consists of a large step text followed by the multiple choice items to which the learner responds and receives immediate feedback.

The tutorial form of CAI adopted by the researcher is very much like the Auto-Elucidative form of programmed instruction that is why the CAI program inherited the characteristics of individualization, self pacing and immediate feedback.

Instructional design-

While developing instructional design, the strengths of various learning theories were kept in view and adapted the approach which suited to largest group, objectives of learning and expected outcomes.

Theoretical Foundations of CAI module:

Theoretical orientation of the software used in the present study employs the eclectic approach. Eclectic approach uses principles and techniques from different perspectives as suit the situation at hand (Huffman, Vernoy & Vernoy, 1995).

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Theorists agree that drill and practice software is oriented to behaviourist approach and works well to memorize and refine skills (Roblyer & Edwards, 2000). They further assert that tutorial programmes are associated to cognitivism and also contend that tutorials can be designed to adopt Piaget’s cognitive approach; Tutorials with branching mode of presentations tend to shift their orientation from cognitive to constructivist approach. The computer assisted program used in the present study mainly underlies cognitivist approach but behaviouristic and constructivist orientations are also prevalent in it as:

- A large number of multiple-choice questions incorporated in the program make it drill and practice oriented.
- Its interactive nature, terms explained in the text and text segments followed by quiz in form of ‘Self Assessment Questions’ are associated with cognitive perspective.
- Nature of questions that explores comprehension and application components of cognitive domain and branching mode of presentation due to hyperlinks make the program blended with constructivist approach.

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3.6.2 Developmental phase

The investigator followed the following ICT plan (steps) for developing the module:

i. Development of the program concept with reference to scope.

ii. Development of outlines of the module.

iii. Development of logic flowchart.

iv. Development of the program storyboard.

v. Plan of user interface.

vi. Preparation of scripts for narrations, text and videos.

vii. Plan for the production of music, audio and video.

i. Development of the program concept with reference to scope:

The scope of the module is limited to XII class, Biology students. It will not only cater the XII class students in learning genetics unit of their syllabus but also facilitate them in Pre Medical Test in which genetics unit is given much importance and due weightage.

ii. Development of outline of the module:

Once the scope of the module was decided, the next step was to identify and define the branching of the module. An interactive multimedia presentation differs from a slide and video presentation in terms of capacity of branching. Slide and video presentations are linear whereas multimedia programs have linked associations in different media and these associations are not necessarily linear. The simplest way to define branching for a program is to develop an outline of it. The major heading in the outline become options available to the user in main menu of the program.
UNIT - GENETICS

Part-I   GENETIC BASIS OF INHERITANCE
1   About Mendel
   -Selection of material
   -Selection of character or trait
   -Methodology
   -Terminology
2   Monohybrid Cross
3   Dihybrid Cross
4   Laws of Mendel
   -Incomplete dominance
   -Co-dominance
   -Law of segregation
   -Reciprocal cross
   -Back cross
5   Gene Interaction
   -Quantitative genes
   -Pleiotropy or Pleiotropic genes
   -Multiple alleles
6   Chromosomal Theory of Inheritance
7   Sex Determination
8   Linkage, Crossing over and Gene map
9   Sex Linked Inheritance

Part-II   MOLECULAR BASIS OF INHERITANCE
1.   The DNA
2.   The Search for Genetic Material
3.   Replication
4.   Transcription
5.   Genetic Code and Gene Mutation
6.   Translation
7.   Regulation of gene expression
8.   Human Genome Project
9.   DNA Finger printing

Fig.3.2 Outline of the module-
iii. Development of the logic flow chart:

After preparing outlines of the module next step was the development of logic flow chart. Developing a logic flow chart is very important, especially in an interactive multimedia module. Graphically speaking flow chart provides a roadmap for the development of the proposed multimedia program.

**Fig. 3.3 Logic flow chart of the module**

![Logic flow chart of the module](image-url)
iv. Development of the program storyboard:

The storyboard represents the proposed multimedia project graphically. The storyboard extends ideas presented in the program script with a series of templates upon which the multimedia applications are used. These templates may be of following types-

- Logic flow and branching sequence
- Storyboard template
- Animation sequence template
- Button description template
- Audio description template
Multimedia Module Storyboard

Application Logic Flow and Branching Sequence

Project name: _________________
(Self Paced Module)
Script prepared by: _________________
Scene No.: _________________

Page No.: _____of ______

LOGIC FLOW CHART OF THE MODULE

Main Menu

- Genetic Basis of Inheritance
  1,2,3,4,5,6,7,8,9

- Molecular Basis of Inheritance
  1,2,3,4,5,6,7,8,9

Identified scene no. ________________________________
Please define logic flow of ________________________________
v. Plan of user’s interphase:

The user’s interphase is how the user interacts with the program content. It includes navigation buttons, text fields, graphics, animations, audio resources, self-assessment questions, feedback/reinforcement and other means of support (forward-backward arrows, volume control etc.) to the users to achieve the goals. While planning user’s interphase psychological principles of learning were given due importance.

vi. Preparation of scripts for narrations, text and videos:

Developing specifics and detailed scripts (descriptions) for text, audio (narrations, music or sound effects) and video is the next step of developing a program.

vii. Plan the production of music, audio and video:

While planning a multimedia program (music, audio, video) following guidelines should be considered of utmost importance, to avoid problems-

- Keep cognitive load low with simple, consistent screen design and sparing use of text, sound, motion and colour.
- Avoid dividing learner’s attention: use various media elements such as text, graphics and sound.
- Use colour, arrows, shading and sound sprangly to direct learner’s attention to important part of the program.
- Keep the information visible on screen, learners need to respond to question.
- Encourage dual encoding by using concrete words and different media (for example text, graphics and sound) to reinforce the information/content.
- Video or simulations should be made as real as possible.
ICT selection-

The investigator selected the required hardware and software for each element of CAI module.

Required basic configuration of the Computer system:

- Window XP/ Vista window
- Processor P IV, Core dual/ Core2dual
- Installation of Flash player 10.0
- Best screen resolution 1024x1024 size
- USB Port/ CD-Rom
- Sound card/ speakers
- At least 276 MB disc space

Production-

Investigator has developed the module with the help of appropriate software and I.T. experts.

Validation of Computer Assisted Instruction module:

CAI module assessment tools for the experts and the teachers were developed by the investigator herself.

Another criterion for validation of module used was 90/90 criterion i.e. if at least 90% students scored 90% or more. To achieve this criterion required improvements were made in the module.
3.7.0 G. C AHUJA GROUP TEST OF INTELLIGENCE (GGTI)

Intelligence level of the subjects was assessed using G. C Ahuja Group Test of Intelligence developed by Dr. G. C Ahuja.\(^7\)

3.7.1 Purpose of group test of intelligence;

Purpose of group test of intelligence is to assess the general mental ability of subjects of age 13 to 18 years studying in English medium secondary schools. The test was developed by Dr. G. C Ahuja in a manner to reduce, as much as possible, the influence of cultural climate and educational level.

3.7.2 Format of the test:

There are 135 items in the scale which are distributed in eight sub-tests as shown in the following table.

**Table 3.3: Number of items and time-limit for each sub-test in GGTI**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Sub-test</th>
<th>Number of items</th>
<th>Time limit (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Following directions</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>II</td>
<td>Classification</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>III</td>
<td>Analogies</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>IV</td>
<td>Arithmetic reasoning</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>V</td>
<td>Vocabulary</td>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>VI</td>
<td>Comprehension</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>VII</td>
<td>Series</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>VIII</td>
<td>Best answer</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>135</strong></td>
<td><strong>32</strong></td>
</tr>
</tbody>
</table>

3.7.3 Reliability & Validity:

Reliability of G. C Ahuja Group Test of Intelligence (GGTI) Scale estimated by Split half method which is 0.974±0.003, which is a very high correlation and hence is very dependable.

Validity of GGTI scale is 0.69±0.47.

3.7.4 Scoring:

Scoring was done with the help of stencils provided with scale. Stencils were so adjusted that the page numbers were visible through the holes of the scoring stencil. Then the correctly marked answers were visible through the holes. Correctly marked answers were counted and written in the left margin against each sub-test of that page. If more than one alternative were marked by the subject, it was to be considered wrong.

The scores from different pages of answer sheet were transferred in a table on the front page and added, then according to norms of the scale manual, table 5 and table 6 were used to get intelligence level.

3.8.0 GENETICS ACHIEVEMENT TEST

A test that is designed to measure performance in an activity area, after a period of training. An achievement test is intended to measure the outcomes of learning in relation to the objectives of learning the subject. So the test consists of items based on objectives. The individual is expected to answer the test usually within a prescribed time. The total score of an individual in an achievement test gives an index of his/her ability. Achievement tests are either standardized or informal i.e. teacher made.

Genetics Achievement Test was developed by investigator with the help of supervisor to measure the achievement of students in Genetics. Its construction and description is as follows:
3.8.1 Instructional objectives:

The first and the most important step in planning a test was to identify the instructional objectives. Investigator categorized the major objectives as knowledge, comprehension, and application.

3.8.2 Design:

The second step in planning a test was to make the ‘Design’. The design specifies weightage to

- Instructional objectives
- Units
- Types of questions

A conscious attempt was made while constructing multiple-choice items to enable the students assess their knowledge and comprehension of the text. Such items were also included which invited the students to apply their knowledge and comprehension.

There was no criterion available to decide the proportion of items measuring knowledge, comprehension and application components of achievement. Researcher worked out the required proportion of emphasis for various levels of cognitive domain by classifying the objectives of teaching genetics in terms of the taxonomy of cognitive domain. Multiple-choice items to assess knowledge, comprehension and application were included in CAI program accordingly. Text material in the CAI program was the same as in the textbook.
DESIGN

Subject: Biology (Genetics)

Class: XII

Table 3.4: Weightage to instructional objectives

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Objectives</th>
<th>Marks</th>
<th>%age of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>29</td>
<td>48.34</td>
</tr>
<tr>
<td>2</td>
<td>Comprehension</td>
<td>19</td>
<td>31.66</td>
</tr>
<tr>
<td>3</td>
<td>Application</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>60</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3.5: Weightage to Content/subject units

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Units</th>
<th>Marks</th>
<th>%age of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Genetic basis of inheritance</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Molecular basis of inheritance</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>60</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3.6: Weightage to types of questions

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Forms of questions</th>
<th>Marks per question</th>
<th>Number of questions</th>
<th>Total marks</th>
<th>%age of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Multiple Choice Questions</td>
<td>1</td>
<td>60</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>60</td>
<td>100</td>
</tr>
</tbody>
</table>
3.8.3 Blue print:

Next step was preparation of blue print. The planned design was brought into action through blue print. Researcher decided how all questions were to be distributed over different objectives and content areas so as to obtain the weightage decided in the design. The three dimensions of the blue print consisted of content area in horizontal rows and objectives and forms of questions in vertical columns.

**Table 3.7: Blue print of Genetics Achievement Test**

Subject: Biology (Genetics)                                      Maximum Marks: 60

Class: XII                                                      Time: 1hr. 30 min.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Content</th>
<th>Instructional Objectives</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Knowledge</td>
<td>Comprehension</td>
</tr>
<tr>
<td><strong>I</strong></td>
<td>Genetic basis of inheritance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>About Mendel</td>
<td>2</td>
<td>----</td>
</tr>
<tr>
<td>2</td>
<td>Monohybrid Cross</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Dihybrid Cross</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Laws of Mendel</td>
<td>2</td>
<td>----</td>
</tr>
<tr>
<td>5</td>
<td>Gene Interaction</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Chromosomal Theory of Inheritance</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Sex Determination</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Linkage, Crossing over &amp; Gene map</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Sex linked inheritance</td>
<td>2</td>
<td>----</td>
</tr>
<tr>
<td><strong>II</strong></td>
<td>Molecular basis of inheritance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>The DNA</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>The Search for Genetic Material</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Replication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4</td>
<td>Transcription</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Genetic code &amp; Gene Mutation</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Translation</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Regulation of Gene expression</td>
<td>2</td>
<td>----</td>
</tr>
<tr>
<td>8</td>
<td>Human Genome Project</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>DNA Fingerprinting</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>29</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Percentage</td>
<td>48.33%</td>
<td>31.66%</td>
</tr>
</tbody>
</table>

3.8.4 Writing of Questions:

After finalizing the blue print the researcher framed 124 items.

3.8.5 Marking Scheme:

The fifth step was to prepare the ‘Marking Scheme’ i.e. scoring key. The marking scheme helps to prevent inconsistency in judgement. Researcher prepared the scoring key for the developed achievement test.
3.8.6 Try-out:

Overall try-out consisted of Initial try-out and group try-out.

*Initial try-out* - Initial try-out was done in two phases. In the first phase the developed test along with operational definition and blue print was given to ten experts. On the basis of experts’ suggestions few questions were modified and 14 questions were deleted.

```
INITIAL TRY-OUT

Experts (10) Individual Try-out (15)
```

Fig. 3.5 Phases of initial try-out of Genetics Achievement Test

In the second phase, the modified test was given to fifteen students individually one by one to remove ambiguous items and to find out if there was any ambiguity in language or vagueness in the format of items. However no considerable modification was to be done.

*Group try-out:* The purpose of the group try-out was item analysis. The modified test as product of initial try-out was given to 50 students in a group. The necessary instructions were given and explained properly about attempting the test. The students were required to record their responses on answer sheet according to the instructions. There was no time limit and the time taken by each student was noted down.

3.8.7 Item analysis:

The analysis of student’s responses to objective type test items is a powerful tool for test improvement and for accumulating a bank of high quality items. It is the process of determining the qualities like ‘discrimination’ and Difficulty’ of the individual items of a test. The primary function of item analysis is to find out –

- How far an item can discriminate between different levels of ability? (discrimination index)
• What percentage of the testees fails to answer the item correctly? (difficulty index of each item)

Item analysis is thus the process which leads to the selection of items for the final test which are qualitatively and statistically good.

Item analysis begins after the test has been scored with the help of scoring key. The score of one was assigned for each correct answer and the total scores obtained by a student was the total number of his/her correct responses. The researcher has followed the following steps for item analysis:

• Scores obtained by different students were piled in ascending order.

• The higher group and the lower group of students were identified separately. The higher group was the highest scoring 27% of the total group and the lower group was an equal number of lowest scoring of the total group.

• The number of individuals doing each item correctly in the top and bottom groups were counted and recorded.

• Number of testees choosing each alternative answer was found out and recorded.

Difficulty value (Index):

The difficulty index is defined as the percentage of the group who answered the items correctly. The larger the value of the index of the test, the easier the item is.

\[
\text{Difficulty Index} = \frac{R_H + R_L}{N_H + N_L} \times 100
\]

Where

- \(R_H\) = Number of students in the higher group who answered the items correctly
- \(R_L\) = Number of students in the lower group who answered the items correctly
- \(N_H\) = Number of students in the higher group
- \(N_L\) = Number of students in the lower group

**Table 3.8: Interpretation of difficulty index**
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Difficulty Index</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Below 20%</td>
<td>Difficult</td>
</tr>
<tr>
<td>2</td>
<td>20% to 50%</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>50% to 80%</td>
<td>Best</td>
</tr>
<tr>
<td>4</td>
<td>80% to 100%</td>
<td>Very easy</td>
</tr>
</tbody>
</table>

On the basis of above table, the researcher has categorized each item according to their difficulty index as shown in the next table.

**Table 3.9: Analyzed items in terms of difficulty index**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Difficulty Value</th>
<th>Item Numbers</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Below 20%</td>
<td>4, 10, 27, 46, 79, 104</td>
<td>Difficult</td>
</tr>
<tr>
<td>2</td>
<td>20% to 50%</td>
<td>3, 6, 16, 17, 19, 22, 23, 37, 38, 45, 49, 50, 51, 52, 54, 60, 70, 71, 72, 81, 83, 86, 87, 93, 94, 96, 97, 98, 105, 106</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>50% to 80%</td>
<td>1, 2, 5, 7, 8, 9, 13, 28, 32, 33, 34, 35, 36, 43, 44, 53, 57, 58, 64, 65, 66, 68, 69, 73, 74, 75, 77, 82, 84, 85, 88, 90, 91, 92, 95, 100, 109</td>
<td>Best</td>
</tr>
<tr>
<td>4</td>
<td>80% to 100%</td>
<td>11, 12, 14, 15, 20, 21, 24, 35, 26, 29, 30, 31, 39, 40, 41, 47, 48, 55, 56, 59, 61, 63, 76, 78, 80, 88, 99, 101, 102, 103, 107, 108, 110</td>
<td>Very easy</td>
</tr>
</tbody>
</table>

On the basis of above table the items which come under the difficulty index of 20% to 80% were selected and rest were dropped.

Discrimination Index or Validity Index:
Discrimination Index is defined as the measure of the extent to which a test item discriminates or differentiates between the students who performed well in overall test and those who do not performed well in the overall test.

\[
\text{Discrimination Index} = \frac{R_H - R_L}{N_H \text{ or } N_L} \times 100
\]

Where

- \(R_H\) = Number of students in the higher group who answered the items correctly
- \(R_L\) = Number of students in the lower group who answered the items correctly
- \(N_H\) = Number of students in the higher group
- \(N_L\) = Number of students in the lower group

**Table 3.10: Interpretation of discrimination index**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Discrimination Index</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Below 30%</td>
<td>Poor items to be rejected</td>
</tr>
<tr>
<td>2</td>
<td>30% to 60%</td>
<td>Reasonably good</td>
</tr>
<tr>
<td>3</td>
<td>60% to 80%</td>
<td>Good discriminator</td>
</tr>
<tr>
<td>4</td>
<td>80% to 100%</td>
<td>Best discriminator</td>
</tr>
</tbody>
</table>

On the basis of table 3.10, the researcher has categorized each item according to their discrimination index.
Table 3.11: Analyzed items in terms of discrimination index

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Discrimination Index</th>
<th>Item Numbers</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Below 30%</td>
<td>3,4,10,11,12,14,15,17,20,21,24,25,26,27,28,29,30,31,39,40,41,42,46,47,48,49,53,55,56,59,61,62,63,68,69,76,78,79,80,88,89,99,101,102,103,104,106,107,108,110</td>
<td>Poor items to be rejected</td>
</tr>
<tr>
<td>2</td>
<td>30% to 60%</td>
<td>5,7,9,13,18,33,35,36,37,43,44,50,52,58,65,66,67,70,71,72,74,75,81,83,86,87,91,98,100,105</td>
<td>Reasonably good</td>
</tr>
<tr>
<td>3</td>
<td>60% to 80%</td>
<td>5,7,9,13,18,33,34,36,37,43,44,50,52,58,65,66,67,70,71,72,74,75,81,86,87,91,92,93,95,96</td>
<td>Good discriminator</td>
</tr>
<tr>
<td>4</td>
<td>80% to 100%</td>
<td>1,6,22,23,38,45,51,54,73,77,82,84,90,94,97,109</td>
<td>Best discriminator</td>
</tr>
</tbody>
</table>

As shown in the above table if discrimination index value is either equal to or greater than 30% then the item discriminates otherwise not. So, the researcher selected the items which come under the discrimination index of 30% or above.

3.8.8 Reliability:

Reliability is the consistency with which a test measures the dimension it intends to measure. So it refers to the accuracy of measurement of the tests in terms of repeated measurements i.e. test gives almost the same values when repeated measurements are taken with it on the same individual under the same set of conditions.

Reliability estimation:

There are many ways for reliability estimation. The researcher used test retest method for reliability estimation.
The reliability of a test is indicated by reliability coefficient, denoted by ‘r’ and is expressed as a number ranging from 0 to 1, with \( r = 0 \) indicating no reliability and \( r = 1.00 \) indicating perfect reliability. The larger the reliability coefficient, the more repeatable or reliable the test is. Table given below serves as general guidelines for interpreting test reliability.

**Table 3.12: General guidelines for interpreting reliability coefficient**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Reliability Coefficient Value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.90 to 1.00</td>
<td>Excellent</td>
</tr>
<tr>
<td>2</td>
<td>0.80 to 0.89</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>0.70 to 0.79</td>
<td>Adequate</td>
</tr>
<tr>
<td>4</td>
<td>0 to 0.70</td>
<td>May have limited applicability</td>
</tr>
</tbody>
</table>

Researcher computed reliability coefficient of the test as 0.861

3.8.9 Validity:

Validity is the fidelity of the test in terms of the quality it intends to measure. A test is valid if it truthfully measures the criterion it claims to measure.

The purpose of the present investigation and the nature of the test items restricted the use of very exhaustive statistical techniques to validate the test.

The test was validated against the criterion of ‘Content validity’. The content validity is concerned with adequacy of sampling of a specified universe of content.

To determine the content validity the test items and a list of outcomes were given to the panel consisting of ten experts in subject matter.

The test was once again revised and the final form of the test with sixty items was ready to use. It takes sixty minutes on an average to attempt.
3.9.0 REACTION TOWARDS CAI SCALE FOR STUDENTS

3.9.1 Purpose of RTCAIS:

Reaction Towards CAI Scale assesses the usability of the developed CAI module. The usability could be measured in terms of ease/comfort with which the set objectives could be achieved with the help of developed CAI module in a particular environment. The aim of usability testing was to identify problem area, and extracting information concerning problems, difficulties, weaknesses and areas for improvement. CAI module should be enjoyable to use and aesthetically pleasing to the users. User satisfaction should be within acceptable levels of users cost in terms of tiredness, discomfort, frustration and individual effort so that satisfaction causes continued and hence usage of CAI module. Motivational elements including colour, graphical images, animation and sound in the interactive multimedia can motivate the user and increase satisfaction.

3.9.2 Description of RTCAIS:

The scale consists of the following three dimensions according to different weightage given to each:

- Content organization
- Communication and innovation strategy
- Content effectiveness

Table 3.13: Weightage to different dimensions of RTCAIS

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Dimensions</th>
<th>Weightage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Content organization</td>
<td>36%</td>
</tr>
<tr>
<td>2</td>
<td>Communication and innovation strategy</td>
<td>36%</td>
</tr>
<tr>
<td>3</td>
<td>Content effectiveness</td>
<td>28%</td>
</tr>
</tbody>
</table>
The method of the assessment of each dimension is based on five point scale i.e.

1. VG - Very Good
2. G - Good
3. A - Average
4. P - Poor
5. VP - Very Poor

The scale in its final form consists of 25 items.

3.9.4 Scoring

All the items of the scale are positively worded. Items were given a score of 5, 4, 3, 2, and 1 for ‘very good’, ‘good’, ‘average’, ‘poor’, and ‘very poor’ respectively. The sum of these values gives the effectiveness of developed CAI module.

The total score varies from 25 to 125 showing least effective to highest effective.

3.10.0 PERFORMA FOR ASSESSMENT OF GENETICS CAI MODULE FOR EXPERTS

3.10.1 Purpose of assessment by experts:

Purpose of assessment by experts was to assess the applicability/validity of the developed CAI module, to identify problem area, and extracting information concerning problems, difficulties, weaknesses and areas for improvement.

3.10.2 Description of Assessment Tool of CAI for Experts:

The scale consists of the following three dimensions according to different weightage given to each-

- Content
- Organization of the Content
- Language of the content
• Presentation of the content
• Evaluation part of the module

Table 3.14: Weightage to different dimensions of assessment performa of CAI module for experts

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Dimension</th>
<th>Weightage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Content</td>
<td>26.08%</td>
</tr>
<tr>
<td>2</td>
<td>Organization of the Content</td>
<td>17.39%</td>
</tr>
<tr>
<td>3</td>
<td>Language of the content</td>
<td>13.04%</td>
</tr>
<tr>
<td>4</td>
<td>Presentation of the content</td>
<td>21.73%</td>
</tr>
<tr>
<td>5</td>
<td>Evaluation part of the module</td>
<td>21.73%</td>
</tr>
</tbody>
</table>

The method of the assessment of each dimension is based on five point scale i.e.

1. SA- Strongly Agree
2. A- Agree
3. CS-Can’t Say
4. D- Disagree
5. SD-Strongly Disagree

The scale in its final form consists of 23 items.

3.10.4 Scoring

All the items of the scale are positively worded. Items were given a score of 5, 4, 3, 2, and 1 for ‘strongly agree’, ‘agree’, ‘can’t say’, ‘disagree’, and ‘strongly disagree’ respectively. The sum of these values gives the effectiveness of developed CAI module.
The total score varies from 23 to 115 showing least effective to highest effective.

**III Post development phase**

Investigator conducted an experiment to check the educational effectiveness of developed CAI module. Investigator used Two Groups, Randomized Matched Subjects, Post-test-Only Design.

**3.11.0 EXPERIMENTAL PROCEDURE**

The experimental procedure was executed. The procedure comprised of three stages- the first stage involved the formation of two groups on the basis of matched randomization using intelligence level as matching criterion. Then a coin was tossed to designate the groups as experimental and control group.

3.11.1 Treatment

After the formation of experimental and control group on the basis of matched randomization using intelligence level as criterion for matching, two groups were given specific treatment. To find out efficacy of the independent variables, the experimental variables were manipulated in form of teaching based on Computer Assisted Instruction and Traditional Teaching. The experimental group was given a demonstration for using and learning through CAI and subjects were provided with self instruction module. Control group was taught through traditional teaching strategy. The teaching learning process was carried out for two months. Same topic ‘Genetics’ was taught to both the groups. The treatment was conducted by the investigator in both groups so as to avoid teacher variable and maximum precision.
3.11.2 Post test

Immediately after the treatment was over, the subjects of both the groups were administered the post-test i.e. achievement test in Genetics. In this way post-test scores were obtained on achievement test in genetics, of both the groups.

3.11.3 Reaction Towards CAI Scale

The subjects of experimental group were also administered the ‘Reaction Towards CAI Scale’ (RTCAIS) to obtain users’ reaction towards the CAI module.

3.11.4 Retention test

After a time span of four weeks, subjects of both the groups were made to undergo the retention test. The same achievement test as in the post-test was used to obtain retention scores. This was done to compare the retention efficacy of the independent variables i.e. CAI and traditional teaching strategy.

3.11.5 Statistical techniques employed

Mean, Standard Deviation, t-test and Coefficient of Variation were employed using MS-Excel 2007.

Table 3.15 : Statistical techniques employed for data analysis

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Objectives</th>
<th>Hypotheses</th>
<th>Applied statistical techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>To develop computer assisted instruction module in Biology for class XII.</td>
<td>---</td>
<td>Flash software</td>
</tr>
<tr>
<td>2</td>
<td>To assess the validation of computer assisted</td>
<td>---</td>
<td>Content validity by</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experts &amp; 90/90 criterion</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>--------------------------</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>To compare the achievement of the students with respect to computer assisted instruction and conventional teaching in the subject of Biology.</td>
<td>There is no significant difference in the mean achievement score of the students with respect to computer assisted instruction and conventional teaching in the subject of Biology. t-value</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>To compare the achievement of the students on the basis of sex with respect to computer assisted instruction and conventional teaching in the subject of Biology.</td>
<td>There is no significant difference in the mean achievement score of the students on the basis of sex with respect to computer assisted instruction and conventional teaching in the subject of Biology. t-value</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>To compare the achievement of the students on the basis of intelligence with respect to computer assisted instruction and conventional teaching in the subject of Biology. -High Intelligence -Average</td>
<td>There is no significant difference in the mean achievement score of the students on the basis of their intelligence level with respect to computer assisted instruction and conventional teaching in the subject of Biology. t-value</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
</tbody>
</table>
|6 | To compare the achievement of the students on the basis of different learning objective levels with respect to computer assisted instruction and conventional teaching in the subject of Biology.  
- Knowledge  
- Comprehension  
- Application | There is no significant difference in the mean achievement score of the students in different learning objective levels with respect to computer assisted instruction and conventional teaching in the subject of Biology. | **t-value** |
|7 | To study the users’ reaction towards computer assisted instruction. | Experimental group students possess favourable reaction towards various aspects of Computer Assisted Instruction. | **Coefficient of Variation** |
|8 | To compare the retention of the students in Genetics in control and experimental group. | There is no significant difference in the mean retention score of the students with respect to computer assisted instruction and conventional teaching in the subject of Biology. | **t-value** |