Chapter IV

Development of Tools and Learning Material
CHAPTER – IV
DEVELOPMENT OF TOOLS AND LEARNING MATERIAL

4.1 DEVELOPMENT OF ACHIEVEMENT TEST

‘Achievement Testing’ refers to the assessment of the outcome of formal instruction in cognitive domain (Dwyer, 1972). It can also be thought of as a sample of indicator of a student’s knowledge taken at a particular point in time (Ebel, 1979). It aids both the teacher and the student in assessing learning readiness, monitoring learning process, diagnosing learning difficulties and evaluating learning outcome (Gronlund, 1977).

As the investigator could not lay hands on appropriate standardized achievement test in Biology, on the selected topics the need was felt to develop one so as to evaluate the outcome of instructional strategies. The test was developed on the three selected topics: (a) STRUCTURAL ORGANISATION OF CELL, (B) CELL DIVISION, AND (C) PHOTOSYNTHESIS.

4.1.1 Planning of the Test

Planning of the test is an essential step for the construction of a test. According to Mehrens (1978), in developing a specific measuring instrument, the first task is to identify and describe objectives, then a table of specifications or a Blue print should be constructed and finally there should be a match between every item and every instructional objective.

Stanley and Hopkins (1978) observed that the planning stage of a test should include nature of the test and test items and a statement of conditions under which it will be administered.
4.1.2 Construction of the test

Following steps were followed in the construction of the test.

The specific objectives selected were knowledge, comprehension and application in the cognitive domain in hierarchy viz.

- Knowledge which includes reproduction of all forms of information whether it be that of facts, methods or theories.

- Comprehension involves reproduction of facts and application of theories or methods in the manner in which students have been instructed.

- Application takes into account application of theories, methods of facts to a new situation which the student had not encountered earlier.

- Analysis implies direction of logical fallacies in arguments, detects cause and effect relationship and recognizes unwanted analogies.

- Synthesis involves proposing of ways of testing hypotheses, by integrating the results of an experiment, developing a plan or procedure according to the given qualifications.

- Evaluation involves comparison of major theories, laws and generalizations and to draw conclusions from these comparisons.

A table of specification of items for each category of objectives has been given under Table 4.1
Table 4.1
Blue Print of Achievement Test

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Topic</th>
<th>Weightage</th>
<th>Total</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>Knowledge</td>
<td>Understanding</td>
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<tr>
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<td>Structural organization of cell</td>
<td>10</td>
<td>08</td>
</tr>
<tr>
<td>2.</td>
<td>Cell Division</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>3.</td>
<td>Photosynthesis</td>
<td>03</td>
<td>05</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>23</strong></td>
<td><strong>26</strong></td>
</tr>
</tbody>
</table>

4.1.3 Content of the Test

The test devised covered the contents from the following three topics selected for the study.

1. **STRUCTURAL ORGANISATION OF THE CELL**
   1.1 Discovery of cell and its organelles
   1.2 Types of cell, cell size, shape and number
   1.3 Organelles of cell-structure and function
   1.4 Structure of typical plant cell and animal cell
   1.5 Differences between plant cell and animal cell

2. **CELL DIVISION**
   2.1 Introduction to cytokinesis and karyokinesis
   2.2 Mitosis with its stages
   2.3 Significance of Mitosis
   2.4 Meiosis with its stages
   2.5 Significance of Meiosis
   2.6 Importance of crossing over
   2.7 Differences between Mitosis and Meiosis
3. PHOTOSYNTHESIS

3.1 Meaning of Photosynthesis

3.2 Process-Chemical reaction, raw materials required for photosynthesis

3.3 Leaf as a photosynthetic organ

4.1.4 Type of Items

All the items were of multiple choice. Each item has four alternatives out of which one was correct.

4.1.5 First Draft of the Test

Individual Try Out: 60 items were included in the first draft of the test covering the entire content and objectives. Care was taken that no objective remained untested and the language of the test items was unambiguous and the instructions were clear and simple. 10 copies of the test were prepared in English medium and it was administered to ten students of Class X of Govt. Senior Secondary School, Sector 21. Problems faced by the students were noted and given the due consideration at the time of revision of the first draft. A scoring key was prepared and answer scripts were evaluated. On the basis of the performance of the students, discussions were held with the biology teachers and students individually.

4.1.6 Second draft of the Test

Small Group Try Out: In the light of the views of the subject teachers, the achievement test was properly reviewed. As a result of the discussions five items were dropped and four were modified and finally 55 items were retained which formed the second draft of the achievement test.
A sample of 55 students of class X of Shishu Niketan Senior Secondary School, Sector 22D was selected. The second draft was administered to them. The answer scripts were evaluated.

### 4.1.7 Item Analysis

Item analysis of the second draft was done by analyzing the item statistically by finding item difficulty value and discriminative power of items in accordance with **Kelley's method (1939)**. According to it, 27% from Upper can be taken as superior in ability to those 27% in the lower group. In this case 27% students falling under upper and lower category were selected. In each sub group we had 15 students. Difficulty value (D.V.) and Discriminating Power (D.P.) were calculated from these two sub groups making total as thirty students.

For calculation of D.V. and D.P. the following formulae were used.

\[
D.V. = \frac{R_U + R_L}{N}
\]

\[
D.P. = \frac{R_U - R_L}{0.5 N}
\]

Where 
- \(R_U\) = Total number of right responses in the upper group.
- \(R_L\) = Total no. of right responses in the lower group.
- \(N\) = Total number of students in both groups.

The D.V. and D.P. for each item thus computed are given in Table 4.2.
**Table 4.2**

The distribution of D.Ps and D.Vs for each item of Achievement Test

<table>
<thead>
<tr>
<th>S.No.</th>
<th>R_U</th>
<th>R_L</th>
<th>D.V.</th>
<th>D.P.</th>
<th>Remarks</th>
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<tbody>
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<th>D.P.</th>
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<td>0.33</td>
<td>0.4</td>
<td>A</td>
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</tbody>
</table>

The items having D.P. equal to 0.4 or above were accepted while item No. 15, 42 and 47 were modified in the light of complexity of the language. Further the items having difficulty value between 0.2-0.59 were accepted as such and the items whose D.V were between 0.6 – 0.75 i.e. item No. 9, 11, 22, 27 were accepted after revision and modification. There was no need to reject any item on the basis of D.V.’s and D.P.’s.

On the basis of the item analysis for D.V.’s and D.P.’s the final draft of the achievement test was prepared. This test consisted of items which were accepted as such and also those items which were revised and modified in the light of D.P.’s of the items and D.V.’s. Final draft of the test was also according to the weightage assigned to each topic as
well as to the different objectives i.e. Knowledge, Comprehension and Application.

4.1.8 Reliability

Many psychologists and Educationists have defined the term reliability. **Ebel (1966)** defines it as the consistency with which a set of test scores measure whatever they do measure.

**Ross and Stanley (1964)** take it as the degree to which the test agrees to itself. Further **Cattel (1964)** views reliability as an extent to which the test gives the same results with the sample on different occasions.

There are four procedures in common use for computing reliability. These are:

1) Alternative or Parallel form
2) Split-half technique
3) Rational equivalence
4) Test-Retest method

1) **Alternative or Parallel form**

When alternative or parallel form of a test can be constructed, the co-relation between these two forms may be taken as a measure of the self co-relation of the test. The reliability co-efficient becomes an index of the equivalence of the two forms of the test. **Gulliksen (1950)** in Theory of Mental Tests’ defines parallel tests as having equal means, equal variances and equal inter co-relations with each other. But such conditions rarely arise in practical conditions.

2) **Split-half technique**

In this method test is split into two equal halves, commonly done by scoring the odd and even numbers separately. Then the co-relation between scores on the odd and even numbered items is
calculated with the help of Spearman-Brown formula. It suffers from set
backs like –

a) It is ineffective where S.D. of halves are unequal.

b) It fails to take cognizance of the variations in the temporal
factors.

c) It does not suit speed test.

3) Rational Equivalence

Two forms of a test are defined as equivalent when corresponding
items are inter-changeable and when inter-item co-relations are the
same for both forms. Guilford (1954) maintains that it is based on the
assumption of unifactor test and parallel items and in the absence of
such a test the use of the formula is well within doubts.

4) Test-Retest Method

Mouley (1970) remarked, “The test Re-test Method is the only
feasible approach to the establishment of the reliability of the test. The
answer to one question given by a respondent in two instances can be
compared for estimating consistency”. This method measures the
stability of the test and not the internal consistency. In this, the same
test is administered to the same subject twice with some gap of time. The
correlation between two sets of scores obtained on both the tests gives a
test re-test reliability co-efficient.

Keeping the above views test-retest method was found better
option as assumption of unifactor test and parallel items was not met so
option of Kunder-Richardson formula was dropped. Then again as one
form of the test was constructed, parallel forms method was ignored.
Lastly the split half method was discarded as items were not arranged on
the basis of item types.

The test was administered to the 30 students of IX class of Govt.
Senior Secondary School, Sector 21, who were not included in the
experimental sample of population. With a gap of month the test was again administered to the same group. The co-efficient of reliability was found to be 98%.

4.1.9 Validity

Validity of a test refers to the degree to which it measures, what it intends to measures. Mouley (1970) remarked, “The validity of a test must be established prior to its use. Validation is an aspect of its development, not of its use in the solution of the problem”. Regarding the method of establishing the validity of a test, Mouley states, “At the most elementary level, it is necessary for all the tests to have content validity i.e. each question must be related to the topic. There must be an adequate coverage of the overall topic, the question must be clear and unambiguous”. A more adequate approach to validation consists of checking the agreement between responses elicited by the Questionnaire against the criterion. In some cases, it is possible to validate questionnaire responses against the actual behaviour of the respondent. The test was validated against the criterion of content validity. This type of validity consider the adequacy of sampling a specified universe of content. Thorndike and Hogen (1970) maintain that the problem of content validity is parallel to the problem of preparing a blue print for a test and building a test to match the blue print. To determine content validity, the test items and a list of the outcomes were given to the panel consisting of five experts in subject matter and five in test items. Comments on item clarity, its correspondence to the outcomes along with validity and objectivity data were used to make modification in some items. Out of five three experts also solved the test so that the scoring key could be verified. The experts agreed with the investigator on the assignment of test items, 96% of the time. This correspondence was taken as evidence of content validity.
4.1.10 Normality of the test

As only those items were absorbed for achievement test which had the difficulty range within the limit of point .25 to .75, so it can be said to be normal test. The distribution of items on the basis of the difficulty value range is given under Table 4.3.

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<thead>
<tr>
<th>S.No.</th>
<th>Difficulty Range</th>
<th>Frequency</th>
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<td>.26 to .35</td>
<td>07</td>
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<tr>
<td>2.</td>
<td>.36 to .45</td>
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<td>16</td>
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<td>.55 to .65</td>
<td>10</td>
</tr>
<tr>
<td>5.</td>
<td>.65 to .75</td>
<td>02</td>
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</tbody>
</table>

The achievement test thus developed was used as a pre-test and post-test at the experimental stage. A copy of the same has been provided in the Appendix I.

4.2 DEVELOPMENT OF LEARNING MATERIAL

4.2.1 Selection of the Content

In the selection of the content, **Lysaught and William (1963)** advised that the size, ease, depressed level of learning, logical order of material and special need of the learner should be kept in mind. Trying to keep these points in mind, the learning material was based on the contents from the following three topics selected for this study:

1. **Structural Organisation of Cell**
   1.1 Discovery of cell and its organelles
   1.2 Types of cell, cell size, shape and number
1.3 Organelles of cell-structure and functions
1.4 Structure of typical plant cell and animal cell
1.5 Differences between plant cell and animal cell

2. **Cell Division**
   2.1 Introduction to cytokinesis and karyokinesis
   2.2 Mitosis with its stages
   2.3 Significance of Mitosis
   2.4 Meiosis with its stages
   2.5 Significance of Meiosis
   2.6 Importance of crossing over
   2.7 Differences between Mitosis and Meiosis

3. **PHOTOSYNTHESIS**
   3.1 Meaning of Photosynthesis
   3.2 Process-Chemical reaction, raw materials required for photosynthesis
   3.3 Leaf as a photosynthetic organ

4.2.2 **Assumptions about the learner**

The programme to be constructed will serve the population of IX class students. The learners will consist of both male and female students of CBSE affiliated English Medium School falling under Chandigarh (UT). It was kept in mind that the learner have some knowledge of the content material and understood the matter.

4.2.3 **Objectives in the behavioural terms**

These objectives are important as they help us decide as to from where to start and where to end the programme. As Mager (1962) defined an objective as, “The intent communicated by a statement
describing a proposed change in a learner. It is a description of a pattern of behavioural performance we want the learner to demonstrate”.

After the instructions the learners will be able to :-

1. Discriminate between the concepts of Cell, Tissue, Organ and Organism by applying attributes of each.
2. Recall the name of the scientists who coined the term cell
3. Name the largest animal cell out of given choices
4. Name the largest cell in human body
5. Analyse that the organism lacking Nucleus and Membrane bound organelle are prokaryotes
6. Recall that cell wall is only found in plant cell
7. Recall that the outer most layer in an animal cell is plasma membrane
8. Understand that a cell without a Nucleus would also not contain chromosomes as chromatin material is present within a nucleus
9. Categorise chloroplast as the Organelle present only in plant cell
10. Know the other name of suicidal bag of cell
11. Know the scientific name of power house of cell
12. Give the scientific name of Kitchen of cell
13. Comprehend that Lysosomes contain Hydrolytic enzymes that is why they are referred as suicidal bags
14. Know that the membrane surrounding a vacuole is tonoplast
15. List the function of centromere

Contd...
16. Comprehend that the site of respiration (oxidation) within a cell is mitochondria
17. Point out the location of Ribosomes within a cell
18. Understand that the function of ribosomes is to synthesize proteins
19. List the function of centriole out of given choices
20. Recall the term used for the Division of Cytoplasm
21. Name the scientist who coined the term mitosis
22. Recall the term used for the division of Nucleus
23. Explain the occurrence of Genetic variations
24. Understand that the Genes are located on the Chromosomes
25. State the type of cells in which the process of meiosis occur
26. Name the stage that marks the beginning of cell division
27. Tell the stage of Mitosis where maximum condensation of chromosomes occur
28. Understand that the sister chromatids separate during anaphase
29. Point out the nature of first division on of Meiosis
30. Name the stage of Meiosis in which exchange of genes between non-sister chromatids occur from the given information
31. Tell that stage during which reorganization of nuclei start taking place at the poles of the dividing cell
32. Comprehend that uncontrolled Mitosis may result in cancer

Contd...
33. Recall the name of longest stage of Meiosis – I

34. Explain the reason for inheritance of characters in a child (from both the parents)

35. State the process during which the synapsis occur

36. Understand that unicellular organisms can reproduce asexually only by mitosis

37. Tell the point on chromatids where crossing over takes place

38. Recall the name of Nucleic acid containing hereditary information

39. Provide the result of a diploid cell after meiosis

40. Name the stage during which DNA duplicates itself from the given options

41. Recall the number of chromosomes present in each human cell

42. Solve the sum related to mitotic cell division

43. Identify the process which helps in healing of wound

44. Tell the name of process where daughter cell and parent cell have identical chromosomes

45. Point out correctly the ‘Structure’ responsible for presence of characters in an individual

46. Define photosynthesis (orally and in writing)

47. Explain that the conducting tissue in plant consist of both xylem and phloem

48. Identify the source from where the energy is coming for the process of photosynthesis from the given choices

Contd...
49. Select the correct term for plants from the given choices by applying attributes of photosynthesis

50. Name the photosynthetic organelle

51. Recall that chlorophyll is the green pigment

52. Comprehend about the end products of photosynthesis

53. Explain the transformation of energy in photosynthesis

54. Understand the concept of compensation point

55. Analyse that the rate of photosynthesis is highest in red light

4.2.4 Development of Computer Simulation Instructional Package

For preparing educational software which can supplement the classroom teaching, thorough knowledge of the course content and then competence to convert that course into a courseware is a must. Papert (1980) advises that educators see the computer as one sees any other instructional objective. A book for example, has no value in itself. It has value depending on its content, its importance on people's lives and on the purpose to which its users put it. Computer instructional package was prepared especially taking in consideration that personal computers in schools do not have the provisions of movement among pictures. The problem was solved by preparing a package which simulated the real conditions. It was delimited with respect to level and content context. Three topics namely structural organisation of cell, cell division and photosynthesis were selected from the IX class syllabi prescribed by NCERT. The teaching package was prepared in HTML, and then copied on the CD which was then implemented in schools. Since it was teacher directed instructional system package, the overall instructional strategy was planned step by step. Verbal instructions were supplemented with simulations on computer screen. A copy of the Computer simulated instructional material has been provided in Appendix III.