CHAPTER III

DEVELOPMENT AND VALIDATION OF THE MULTIMEDIA INSTRUCTIONAL STRATEGY

As mentioned in the earlier chapter, this chapter presents methodological details, results and discussion in respect of the first objective of the investigation. The objective reads as follows:

> "To develop a duly validated multimedia instructional strategy for teaching the course Biology at VIII std. level."

Necessary details are presented under two sections. Section I provides the details regarding the design followed for studying the objective, development of the instructional strategy, and instrumentation. Details related to the validation of the strategy, have been presented in Section II.

2

SECTION I

DESIGN, DEVELOPMENT OF THE INSTRUCTIONAL STRATEGY AND INSTRUMENTATION

DESIGN

As can be observed from the objective mentioned earlier, it includes two aspects, namely, development of the multimedia instructional strategy and validation of the same for its effectiveness. The developmental aspects include analysis of the course content, specification of the terminal behaviours, identification and sequencing of appropriate instructional components, development of instructional material (software) to be presented through the various components, their initial tryout, and development of instruments for validating the strategy. The strategy has been validated in terms of students' performance on different achievement tests developed by the investigator and the school authorities, their gain on Scientific Attitude Test (pre-test to post-test), and also through their reactions towards working of individual components of the strategy and the strategy as a whole.

DEVELOPMENT OF INSTRUCTIONAL MATERIAL

Identification of the Individual Components of the strategy

It may be recalled from Chapter I that the basic

theme of the study has been to systematise the instructional process for teaching Biology to the students of Std.VIII through a multimedia instructional strategy. The initial step in such an attempt would be the listing down of various broad objectives of science instruction, as they provide some direction for identification and selection of various instructional components to constitute the instructional strategy. As Biology forms a part of the total science programme at secondary school level, the broad objectives of science instruction at this level have been listed below:

1. To provide basic information about science concepts involved in each unit of Biology.

2. To provide opportunities for a practical understanding of the methods of scientists which would give students the confidence to attempt the solutions of problems which they have to face in their individual and social lives.

3. To develop and instill in students the scientific attitude of inquiry and experimentation.

4. To develop certain skills such as drawing, handling and arranging apparatus, etc.

It is quite evident from the objectives specified above that they are diverse in nature. The diversity among objectives calls for organizing a variety of learning

4 experiences. More specifically, it would mean introducing into the instructional process various modes of generating appropriate stimuli and treatment of responses. Today, more than before, a good number of instructional techniques of proven potentials in the achievement of certain instructional objectives are available to educational practitioners. Behavioural sciences have offered principles about human behaviour, application of which has provided various instructional techniques such as PLM, lecture, discussion, seminar, team teaching, etc. Similarly, technological innovations in communication research have provided effective channels for presenting information such as radio, television, films, tape-recorders, video-tapes, overhead projectors, etc.,which could be successfully employed for instructional purposes. It need not be emphasised that all the above mentioned techniques and equipments find their due places in the instructional process. Thus, they form the different instructional components. However, what remains as a challenge is the identification and selection of appropriate components of instruction, and organizing them into an instructional strategy for achieving the various objectives. As discussed in Chapter I, development of such a strategy would be guided by considerations such as instructional objectives to be achieved, learners' characteristics, nature of the course content, the resources available - in terms of both men and material - administrative facilities, and feasibility aspects such as cost of the material, time and schedule involved, etc.

5 In order to facilitate the identification of different instructional components of the multimedia instructional strategy to be designed, the investigator taught Biology for a period of four months to Std. VIII students of the school, namely, Shreyas Vidyalaya, Baroda, wherein the strategy was to be implemented. During this period, the investigator got an insight into certain characteristics of the learners at this level, such as level of attainment of scientific knowledge, language ability, study habits, etc. Also, the organizational pattern of the school, the resources available, etc., were studied in detail. On the basis of the knowledge obtained regarding learners' characteristics, the facilities available in the school and the nature of the course content, possible instructional components to constitute the strategy were identified. A few instructional components like questioning technique, guided discovery, discussions, team teaching, etc., were examined for their utilization in the teaching of Biology for the grade VIII. With the knowledge obtained through this experience and also keeping in view a few specific considerations, the actual instructional components to constitute the strategy were arrived at. The specific considerations kept in view, while identifying different instructional components, are presented below:

Individualized Instruction: A perusal of the literature on individualized instruction would reveal that many techniques are available for individualizing instruction,

6 for example, a Programmed Learning Material (PLM), Modules, Independent Study Plans, etc. Most of these techniques have been tried out in school settings, and many have been the subject of evaluation studies. A good many examples in respect of these techniques along with their effects can be seen in the works of Edling (1970); Weisgerber (1971); Briggs (1974); and Yadav, et al. (1979). The governing principle behind this approach is the learner centered instruction. It is a fact that learning takes place within the individual learner. This fact accords with the internal conditions of learning such as students' desire to learn, willingness to follow directions, attention to the task, attempts to recall relevant information or skills, and receptivity to the guidance of the teacher. Further, it becomes evident through a little reflection that learners once they can read well, learn many skills and acquire most information better and faster from a printed source than from an orally delivered group instruction. Looking to future benefits in the long range, the earlier that the students are taught to accomplish and practice independent learning, the more successful will they become as mature learners. Added to this, at secondary school level, the learners, being at the stage of adolescence, exhibit the characteristic need to be independent. This, when applied to instructional situation, would emphasise individualization of instruction. Self-instructional materials, library work, projects, assignments, etc., can be easily thought of for developing the behaviour of

7

independent learning in learners. However, the above considerations for individualization of instruction should not de-emphasise the - role of the teacher in an instructional situation. Learners, by and large, at secondary school level tend to depend heavily on teachers. This is because of the reason that most of the times they have been exposed to teacher prominent ways of instruction. This necessitates retaining the positive aspects of teacher involvement to facilitate smooth introduction of effective modes of instruction (Yadav and Seshadri, 1980).

Human Interaction: Another aspect which gains importance in the process of instruction is human interaction. For the development of certain higher cognitive abilities and certain affect attributes like objectivity, criticality, open-mindedness, etc., it would require that the learners get enough opportunities for interaction. Hence, it would be appropriate to expose the students to such situations where they would interact with their teacher and peers. In this context, techniques such as small and large group discussions find due places in the instructional strategy.

Learning through Performance: In most of our classrooms instruction goes on in verbal form. In a discipline like science where the concepts are built around the - natural phenomena, learning experiences just in verbal form alone may not suffice. Methods of transmitting knowledge

8 under such a discipline would call for more of observation and recording of the occurrence of the phenomena and understanding them in their operation. This could be achieved by incorporating certain activities in the instructional process - activities which the students can perform at home on an individual basis, or activities which they can perform in groups in the school, and demonstrations of experiments by the teacher. Further, while structuring information about science concepts, by relating them with the daily life situations it could be brought home to students asto how science operates in their own physical and social environment.

Since one of the objectives of science instruction is development of 'scientific attitude' in learners, it becomes necessary to imbibe in them the fact that science is not a finished product, but a process in itself of man's search for truth. This could be imbibed in students by exposing them to literature related to historical development of man's thinking and experimentation through the ages to arrive at principles and concepts in science.

It may have to be mentioned that eventhough identification and selection of the instructional components were done in the light of the several considerations, the role of each component and sequencing of actual activities to be carried out under different components were decided after developing a detailed instructional scheme of all the

activities on the part of the teacher and the students.

The multimedia strategy arrived at comprised of the following instructional components:

1. Introduction by the teacher.
2. Programmed learning and Deviated Programmed learning materials.
3. Lecture method.
4. Team teaching.
5. Inquiry technique.
6. Pupil activities and Teacher demonstrations.
7. Discussion sessions.
8. Audio-visual presentations.
9. Historical background of scientists and scientific inventions.
10. Summaries.
11. Criterion tests and feedback.
12. Exercises and Assignments.

It may be mentioned that not all these techniques have occurred while structuring learning experience for each unit. They have occurred in various combinations in the

different units of the course. The criteria of combination of components and their sequencing have been the specific terminal behaviours listed for the units and their sequence, and the structure of the content matter in the unit. However, a few components such as introduction by the teacher, pupil activities, summaries, criterion tests and feedback, exercises and assignments have occurred in almost all the units. With regard to each of the components and its utilisation, appropriate mode of behaviour on the part of the teacher and students has been spelt out. Ofcourse, this was done after analysing the content to arrive at various units.

Course Content and Task Analysis:

It may be recalled from Chapter II that the present study was a part of the institutional project, namely, 'To develop multimedia instructional strategy for the entire 'science course' of Gujarat Board Syllabus for VIII Std. students' undertaken by CASE, M. S. University of Baroda, Baroda. It was also mentioned that for the present study only 'Biology' formed the course content. The entire course in Biology was analysed in detail. On the basis of this analysis, the course was structured into seven units. Besides the seven units arrived at, an introductory unit was also developed with a view to bringing home to students the importance of studying science, and also instructing them asto how they would be studying it through the developed

11 strategy. In all, a total of eight units was to be presented to students. The exact titles of the units have been presented below:

Unit 1 - Importance of studying science.

Unit 2 - Structure of a cell and its constituents.

Unit 3 - Autotrophic Nutrition.

Unit 4 - Heterotrophic Nutrition.

Unit 5 - Transportation and circulation.

Unit 6 - Respiration and production of energy.

Unit 7 - Excretion.

Unit 8 - Water economy.

Flow charts were developed for the entire course content as well as for the individual units to establish adequate sequencing of the concepts. It may be mentioned that no major deviations in the sequencing of units from that of the text-book was brought about. In other words, the sequence of units were retained as it was prescribed in the text-book. However, a few changes were made as regards the sequencing of concepts under units 2, 3 and 5 are concerned. These changes were made mainly to maintain logical flow in the content included under these units. Specific changes brought about in the sequencing of concepts under these units are presented in Chart I. The concepts included under different units and their sequence are represented in charts (flow charts) 2 to 10. Flow chart 2 presents a comprehensive

picture of the entire course content. The remaining flow charts present content included in units I to VIII separately.

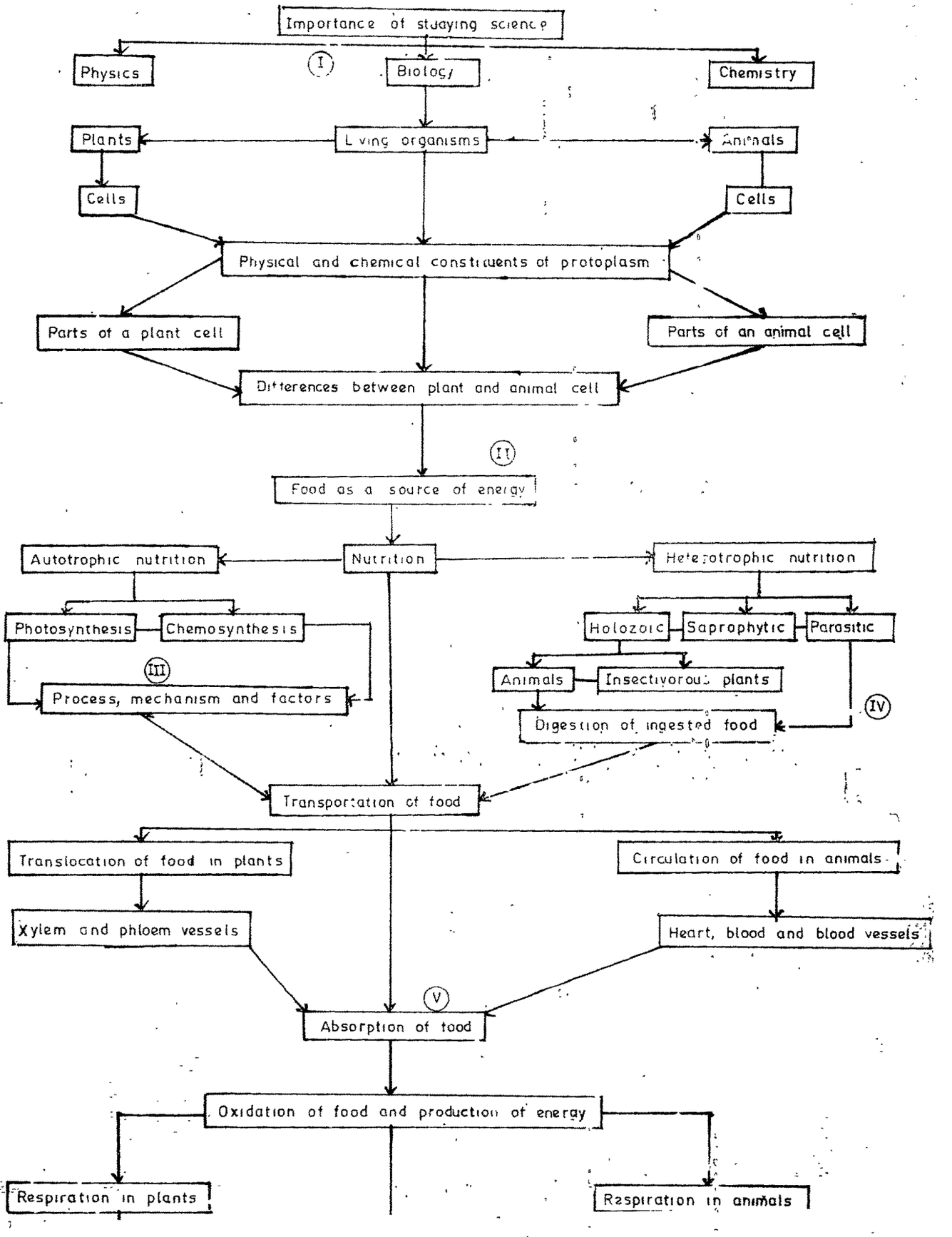
12

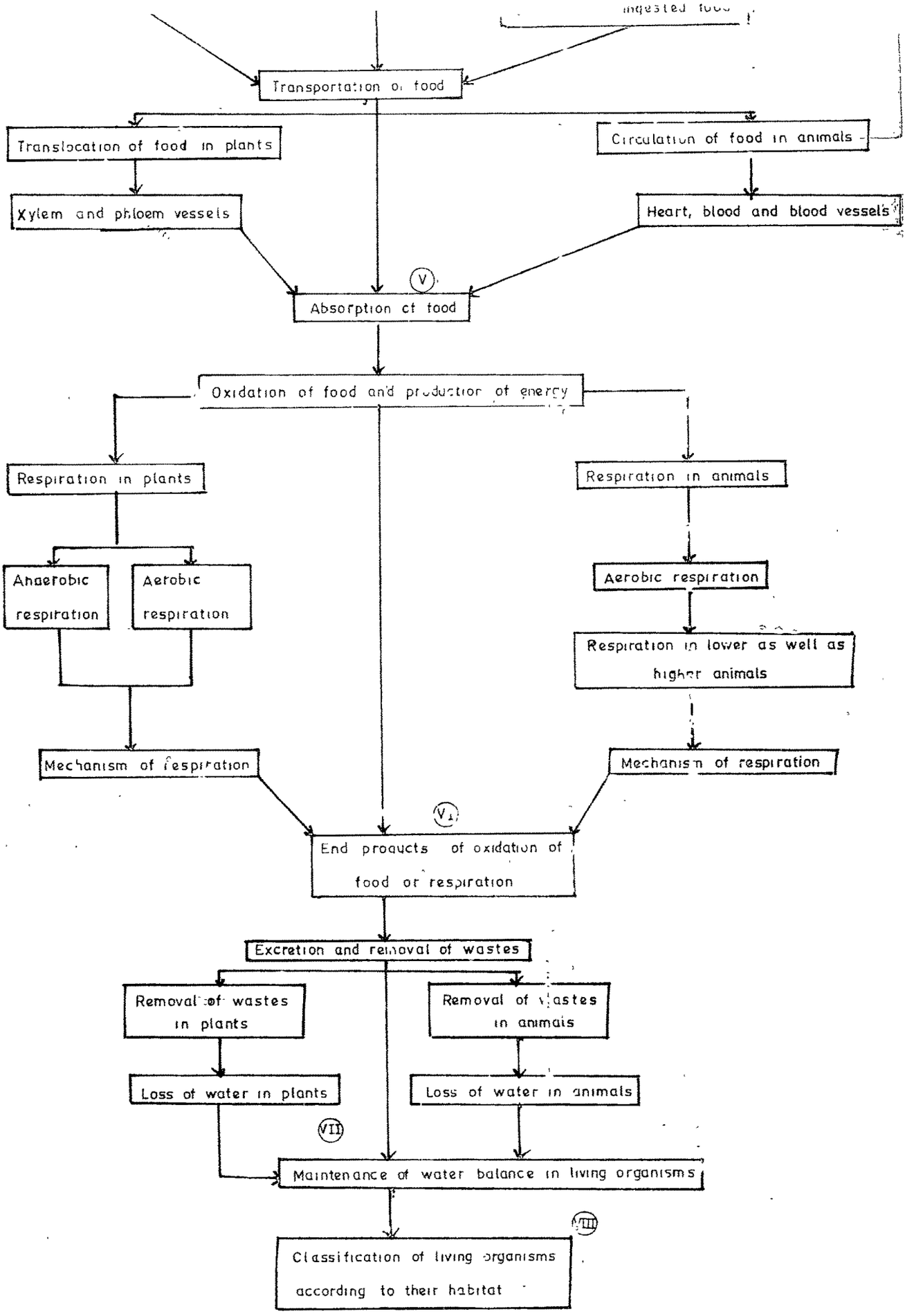
CHART 1

CHART SHOWING CHANGES MADE IN THE SEQUENCING OF CONCEPTS IN UNITS 2, 3 AND 5

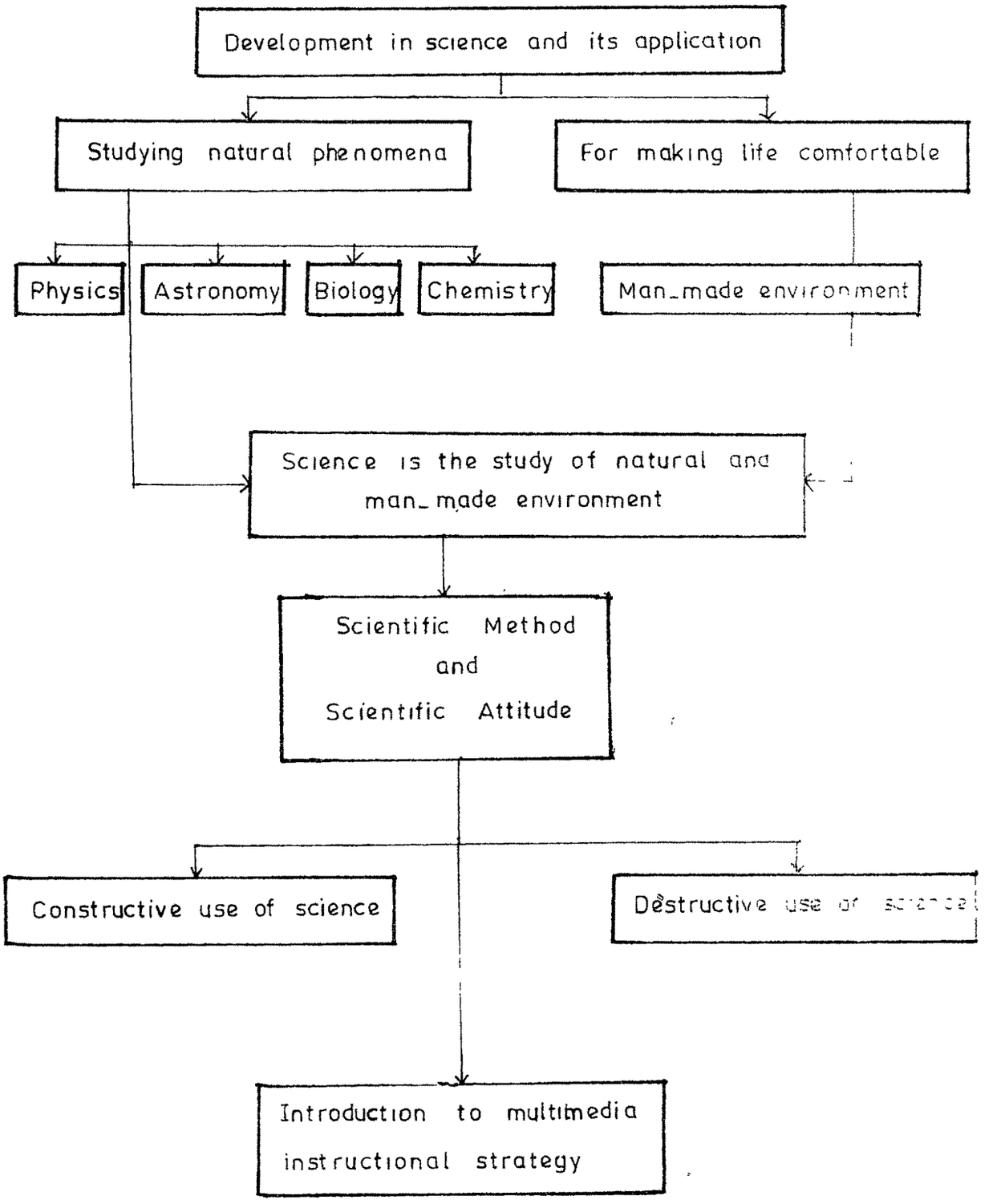
Unit	Sequence of concepts as occurring in the text-book	Changes made in the sequence by the investigator
Unit 2	(a) Cell as a basic unit of life.	(a) Cell as a basic unit of life.
	(b) Organelles found in the protoplasm.	(b) Physical and chemical constituents of protoplasm.
	(c) Physical and chemical constituents of protoplasm.	(c) Organelles found in the protoplasm.
	(d) Cell theory and its propounders.	(d) Cell theory and its propounders.
Unit 3	(a) Concept of Autotrophic Nutrition.	(a) Concept of Autotrophic Nutrition.
	(b) Concept of photosynthesis.	(b) Concept of photosynthesis.
	(c) Factors influencing photosynthesis.	(c) Chemosynthesis.
	(d) Mechanism of photosynthesis.	(d) Mechanism of photosynthesis and chemosynthesis.
	(e) Gaseous exchange.	(e) Factors influencing photosynthesis.
	(f) Carbon cycle.	(f) Gaseous exchange.
	(g) Chemosynthesis.	(g) Carbon cycle.
	(h) Nitrogen cycle.	(h) Nitrogen cycle
Unit 5	(a) Concept of Transportation.	(a) Concept of Transportation in plants and animals.
	(b) Transportation in animals.	(b) Transportation in animals.
	(c) Nature of blood and its functions.	(c) Circulation of blood in man.
	(d) Circulation of blood in man.	(d) Nature of blood and its functions.
	(e) Transportation in plants.	(e) Transportation in plants.

AN OVERALL PICTURE OF THE COURSE STANDARD VIII - BIOLOGY

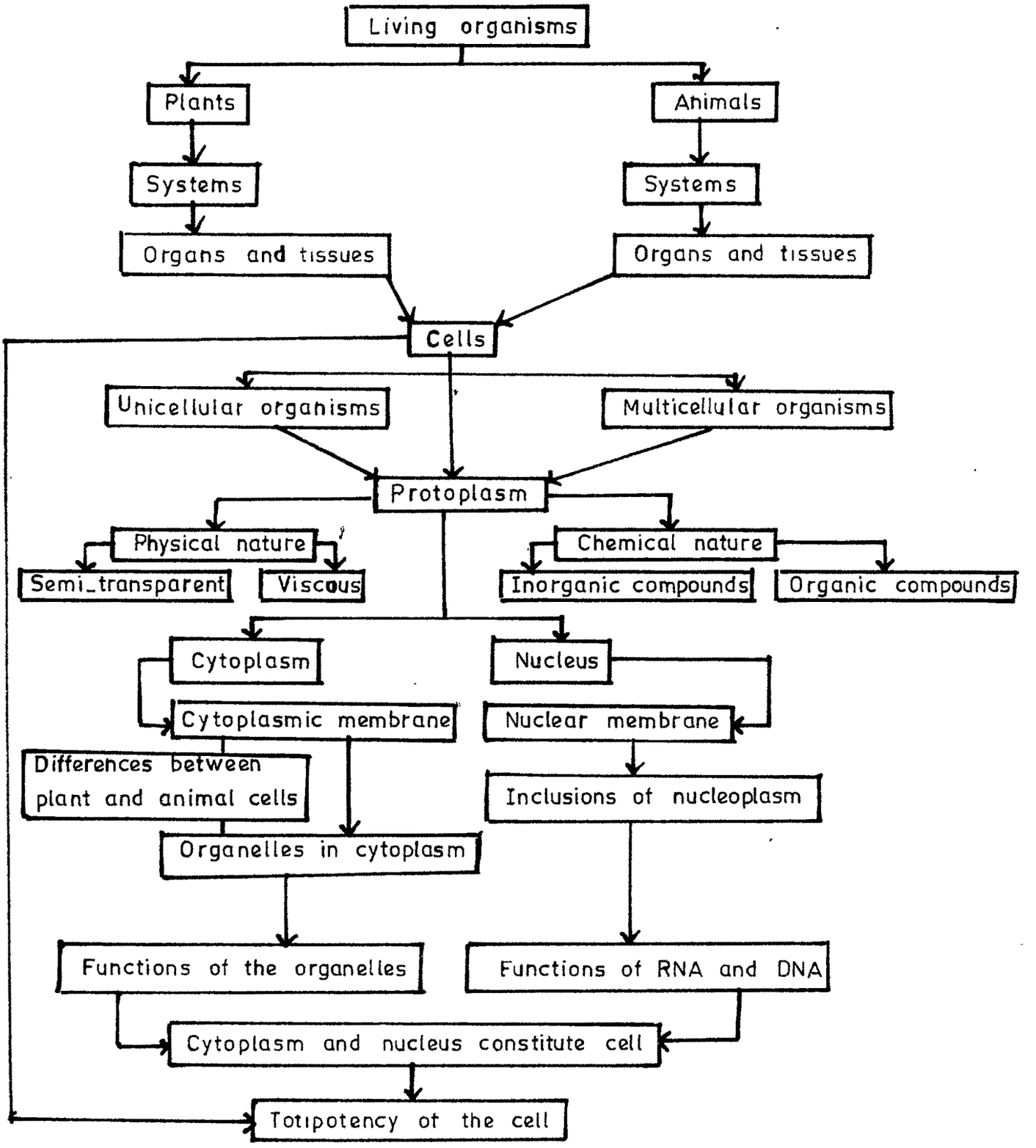



Ingested food
Transportation of food
Translocation of food in plants
Circulation of food in animals
Xylem and phloem vessels
Heart, blood and blood vessels
V
Absorption of food
Oxidation of food and production of energy
Respiration in plants
Respiration in animals
Anaerobic respiration
Aerobic respiration
Aerobic respiration
Respiration in lower as well as higher animals
Mechanism of respiration
Mechanism of respiration
VI
End products of oxidation of food or respiration
Excretion and removal of wastes
Removal of wastes in plants
Removal of wastes in animals
Loss of water in plants
Loss of water in animals
VII
Maintenance of water balance in living organisms
VIII
Classification of living organisms according to their habitat

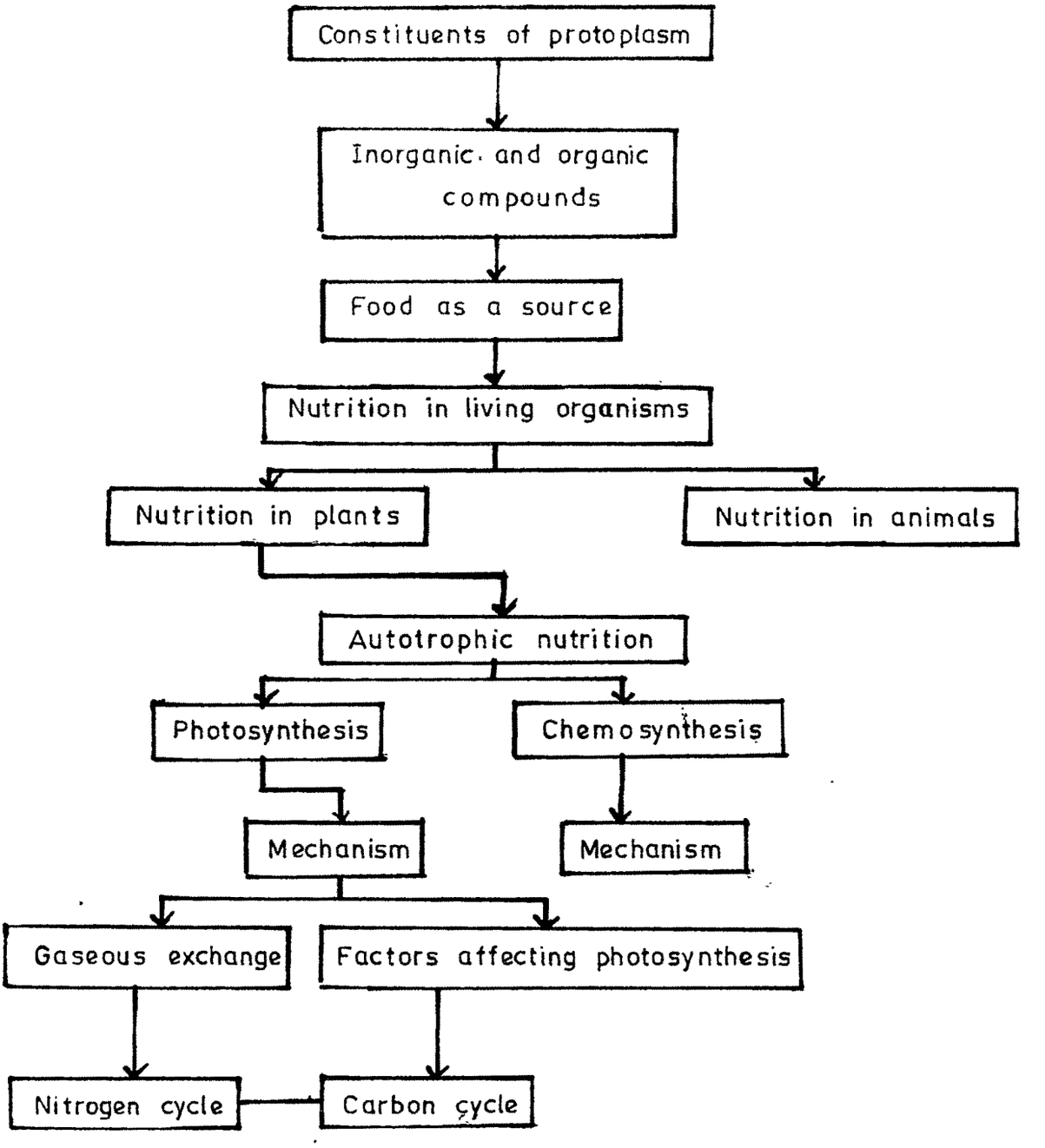
UNIT.I: IMPORTANCE OF STUDYING SCIENCE



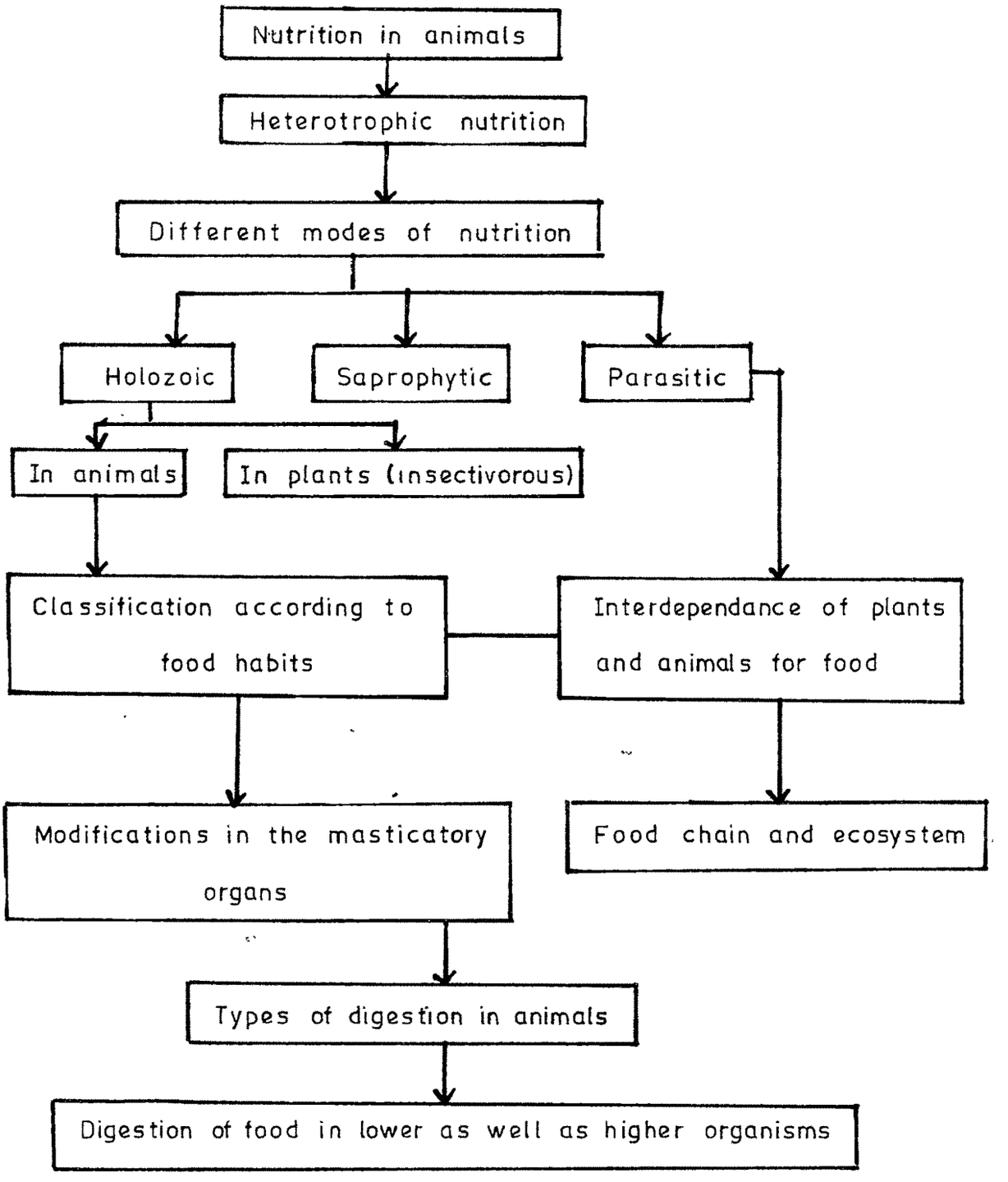
UNIT_II: STRUCTURE OF A CELL AND ITS CONSTITUENTS



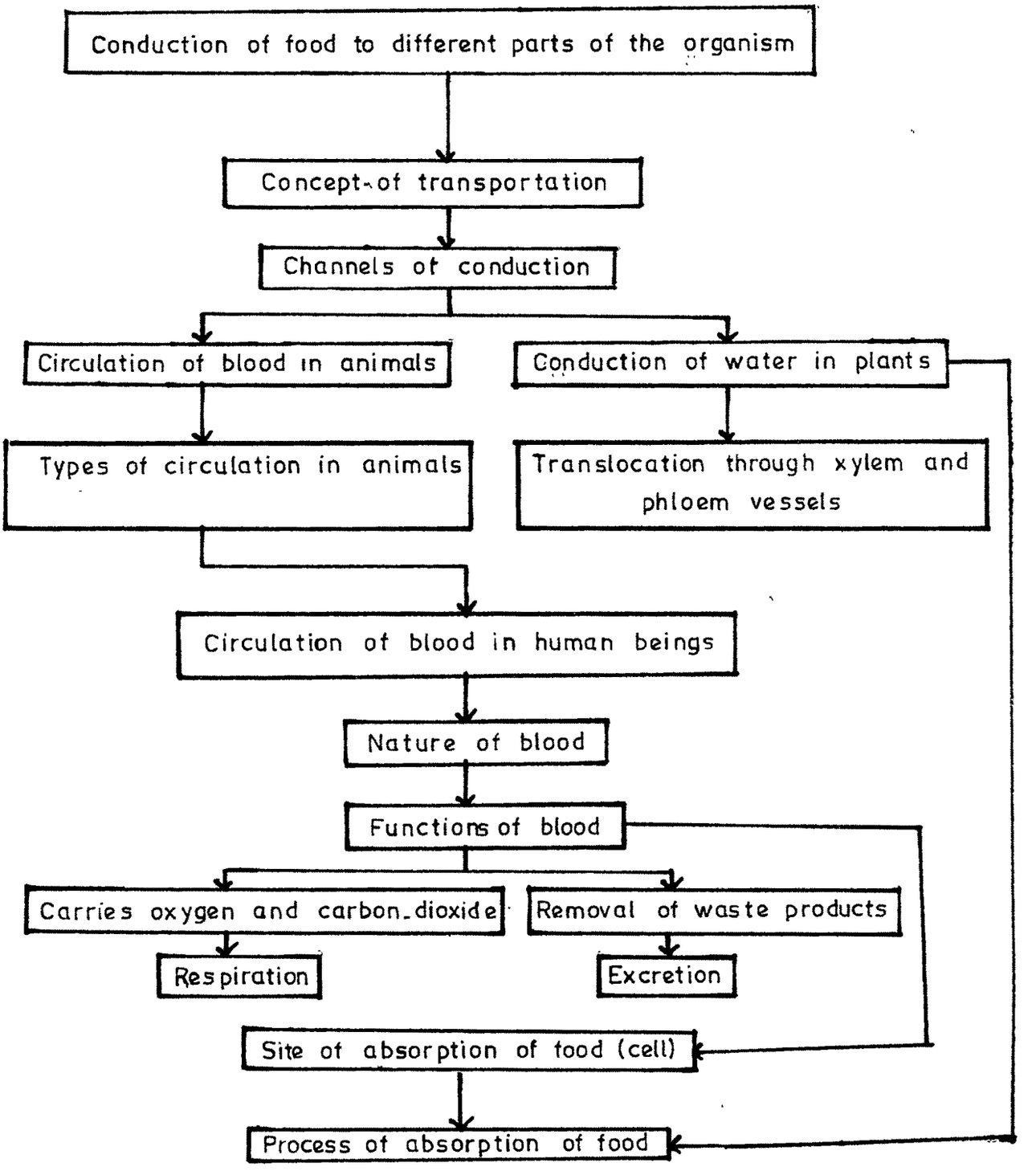
UNIT_III: AUTOTROPHIC NUTRITION



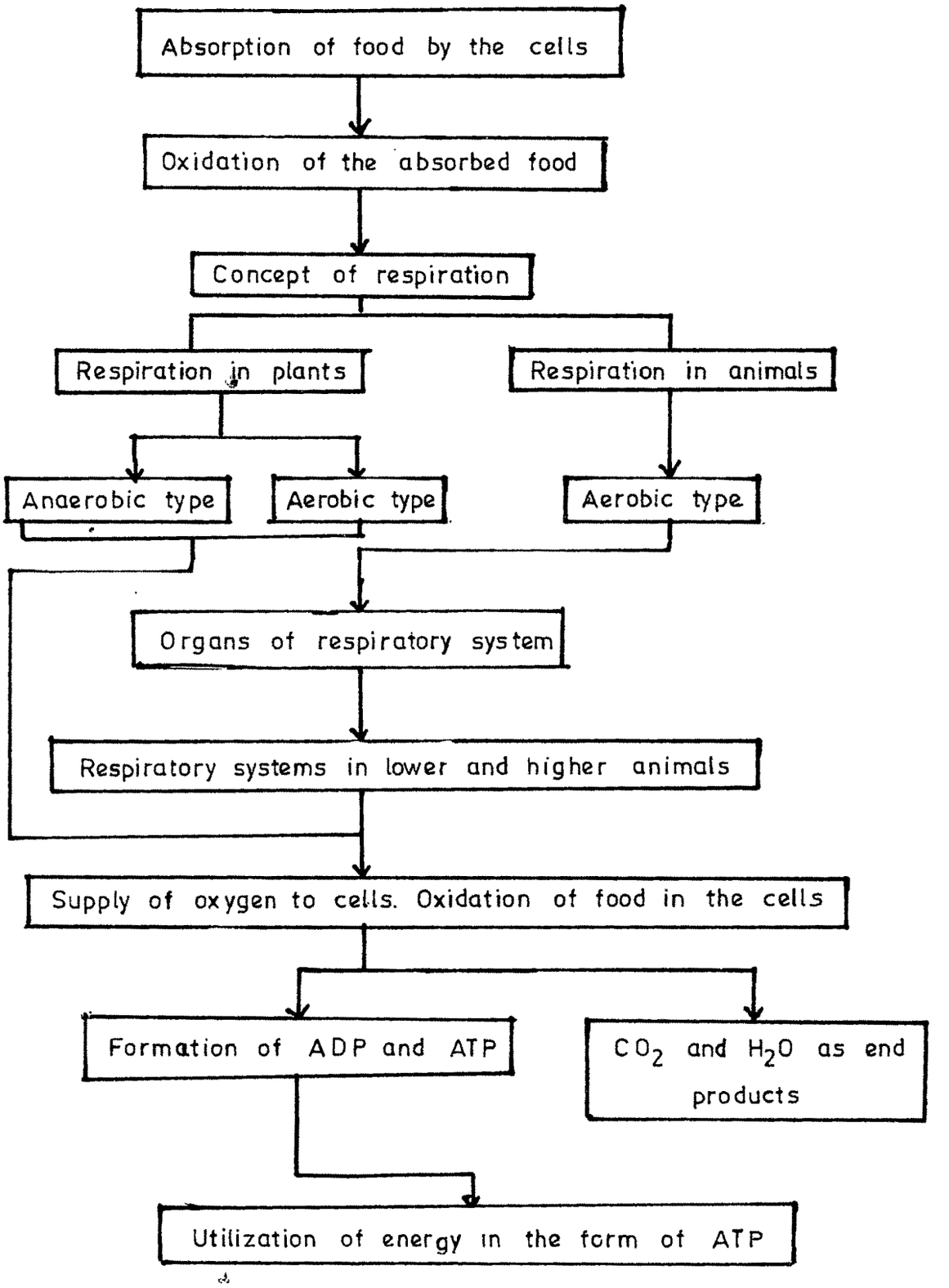
UNIT_IV HETEROTROPHIC NUTRITION



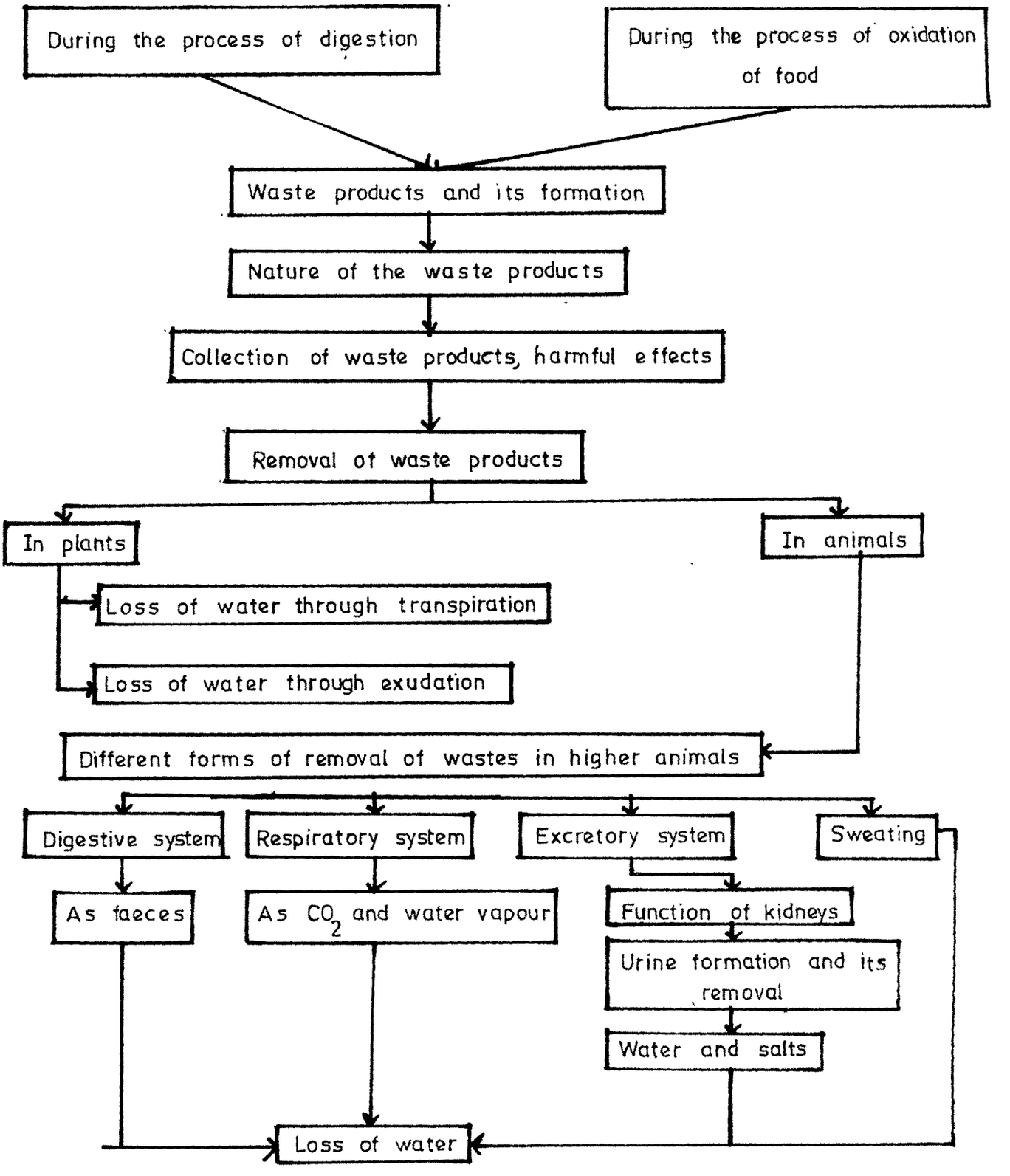
UNIT_V: TRANSPORTATION AND CIRCULATION



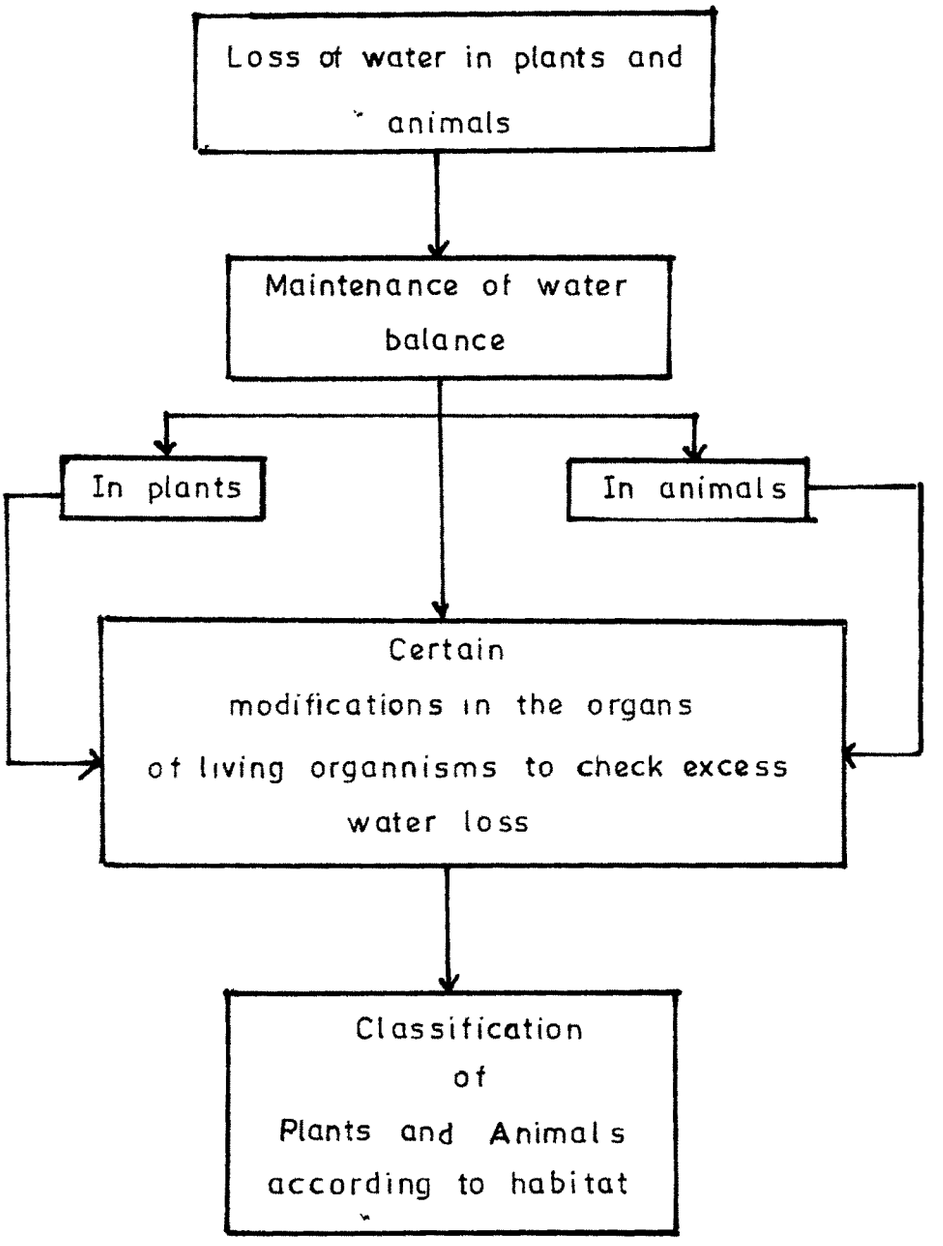
UNIT_VI: RESPIRATION AND PRODUCTION OF ENERGY



UNIT_VII: E X C R E T I O N



UNIT_VIII WATER ECONOMY



13 Content Outline of the Units:

Unit 1: Importance of studying science

(a) Nature of science

(b) Nature of scientific inquiry

(c) Contributions of scientists to the field of knowledge

(d) Advantages of scientific discoveries

(e) Misuse of scientific inventions

(f) How you would study science.

Unit 2: Structure of a cell and its constituents

(a) Organs and systems in living organisms

(b) Cell as a basic unit of life

(c) Physical and chemical nature of protoplasm

(d) Organelles found in protoplasm and their functions.

(e) Cell theory and its propounders.

Unit 3: Autotrophic Nutrition

(a) Concept of autotrophic nutrition

(b) Concept of photosynthesis

(c) Factors influencing photosynthesis

(d) Carbon cycle

(e) Gaseous exchange

(f) Chemosynthesis.

14 Unit 4: Heterotrophic Nutrition

(a) Concept of heterotrophic nutrition
(b) Different modes of heterotrophic nutrition
(c) Different types of ingestion of food
(d) Different types of digestion in animals
(e) Interdependence of animals and plants
(f) Food chain and ecosystem

Unit 5: Transportation and circulation

(a) Concept of transportation
(b) Transportation in plants and animals
(c) Nature of circulation in animals
(d) Nature of blood and its functions.

Unit 6: Respiration and production of energy

(a) Concept of respiration
(b) Types of respiration in plants
(c) Respiration in animals
(d) Mechanism of respiration in animals
(e) End products of respiration.

Unit 7: Excretion

(a) Concept of excretion
(b) Different forms of the removal of waste products.
(c) Mechanism of urine formation in human beings and the role of kidneys.

15 (d) Maintenance of water balance in the body.

Unit 8: Water economy

(a) Concept of how water content is balanced in the living organisms
(b) Need for such a maintenance
(c) Modifications seen in living organisms for this purpose.
(d) Classification of living organisms according to their habitat.

Entering Behaviour and Target Population:

As it was mentioned earlier, the strategy was conceived to teaching the course Biology to VIII std.students. The target population, hence, was VIII std. students. All the students had 'English' as their medium of instruction in all their previous standards. Hence, the requirement of basic ability to read and comprehend simple English was presumed. As regards the concepts included in the VIII std.syllabus, it may be mentioned that they were not totally new in their introduction in the course. Many concepts had been dealt with in their earlier standards in an introductory manner. Since the students have completed those standards successfully, the prerequisites for learning the concepts in the VIII std. syllabus was presumed.

16 Terminal Behaviour:

Taking into consideration the broad objectives of the course and the content included in each unit, terminal behaviours were specified in behavioural terms. Since the first unit formed just an introductory unit, in other words an orientation unit, terminal behaviours were not specified. This unit was intended to bring home to students the importance of studying science, and also how they would be studying it that year. Terminal behaviours specified for the rest of the units have been presented in the pages to follow.

Unit 2

1. Students will recall that plant cell is a bit of protoplasm surrounded by cell wall.

2. Students will recall that animal cell is a bit of protoplasm surrounded by cell membrane.

3. Students will recall the different aspects of cell theory.

4. Given names of biologists, students will recognize the names of the persons who formulated the cell theory.

5. Students will recall that cytoplasm and nucleus are the two major areas of protoplasm.

6. When given names of different chemical

17 compounds present in protoplasm, students will classify them into organic and inorganic compounds.

7. Students will reason out as to why water is important for the life of an organism.

8. Students will reason out as to why a rat fed only on solid food dies, whereas, a rat fed on both solid and liquid food lives.

9. Students will recall the chemical composition of carbohydrates.

10. Students will name atleast three examples of carbohydrates.

11. Students will recall the process of energy formation in cells, namely, conversion of ADP into ATP, and again back to ADP.

12. Students will recall the chemical composition of fats and proteins.

13. Students will name atleast three examples for proteins and fats.

14. Students will reason out as to why amino acids are called as building blocks of proteins.

15. Students will recall the inclusions of nucleoplasm.

18

16. Students will recall the names of the two types of nucleic acids present in cells.

17. Students will reason out as to why certain diseases are called as hereditary diseases.

18. Given the unlabelled diagram of an animal cell, students will label the parts of the cell.

19. Students will differentiate between a plant cell and an animal cell with regard to the Organelles present in them.

20. Students recall one function each of the Organelles present in plant and animal cell.

21. Students will represent the parts of a plant cell diagrammatically.

22. Students will recall the concept of toti-potency of a cell.

23. Students will reason out as to why animal cells need a readily available source of food nutritients.

24. Students will reason out the effect of the removal of nucleus from the cell with regard to the energy formation and transformation of hereditary characteristics.

Unit 3

1. Students will recall that the basic food

19 requirements of all living organisms are carbohydrates, fats and proteins.

2. Students will recall that plants manufacture starch by the process of photosynthesis.

3. After observing Ganong's light screen experiment, students will infer that light is necessary for the manufacture of starch by plants.

4. Students will reason out as to why a plant kept in complete darkness dies within a few days.

5. After observing Molls half-leaf experiment, students will infer that CO_2 is necessary for the manufacture of starch.

6. Students will illustrate with the help of a diagram Molls half-leaf experiment.

7. Students will reason out as to why animals are able to survive ~~x~~ on the world even though they give out large amount of CO_2.

8. After observing hydrilla experiment, students will infer that Oxygen is evolved during photosynthesis.

9. Students will illustrate with the help of a diagram the experiment showing that O_2 is evolved during photosynthesis.

10. Students will reason out as to why green plants are kept in aquarium.

11. Given the equation representing photosynthesis, students will recall the definition of photosynthesis.

12. Students will recall the two major reactions of photosynthesis.

13. Students will recall the role of sunlight in the process of photosynthesis.

14. Students will recall the steps of light reaction.

15. Students will recall the reasons as to why a set of reactions of photosynthesis is called as light reaction.

16. Students will recall the steps of dark reaction.

17. Students will reason out as to why a set of reactions of photosynthesis is called as dark reactions.

18. Given different steps of photosynthesis, students will trace the path of carbon from the atmosphere till the formation of carbohydrates by rearranging the steps.

19. Students will recall the mechanism of gaseous exchange in plants.

20. Students will recall that during chemosynthesis,

21 plants make use of chemical energy for manufacturing their food.

21. Students will reason out as to how CO_2 level is maintained in the atmosphere.

22. Students will reason out the importance of fertilizers for the growth of plants.

23. Students will recall that plants can utilize atmospheric nitrogen only in the form of nitrates.

24. Given different steps involved in the fixation of nitrogen, students will rearrange them in logical order.

25. Students will reason out as to why farmers grow leguminose plants (pulses) after growing paddy, wheat, etc.

Unit 4

1. Students will recall that animals and non-green plants obtain their food from other organisms whether living or dead.

2. Students will recall the three modes of heterotrophism ,namely, holozoic, saprophytic and parasitic.

3. Students will give atleast two examples for each of the mode of heterotrophism.

4. When given two modes of nutrition, students would differentiate between autotrophs and heterotrophs.

22 5. Given the data, students will differentiate between saprophytic and chemosynthetic mode of nutrition.

6. Students will differentiate between producers and consumers.

7. Given the information, students will develop a food chain out of the information.

8. Students will differentiate between intracellular and extracellular digestion.

9. Students will define the process of digestion.

10. Students will recall that ptylin in salive converts starch into sugar.

11. Students will recall the functions of the enzymes present in the digestive juices.

12. Students will recall that insectiverous plants feed on insects and other small organisms.

13. Students will differentiate between symbiosis and parasitism.

14. Students will reason out as to what happens when the whole of small intestine is removed from the body of a human being.

15. Students will reason out as to why starch grains when chewed becomes sweat.

23

16. Students will reason out asto why food is to be chewed well before it is swallowed.

Unit 5

1. Students will recall that the process by which substances are transported from one part of the body to the other is called circulation.

2. Students will recall that the main function of circulatory system is to provide every cell with food, water, and removal of metabolic wastes.

3. Students will recall the mode of transportation in lower as well as higher organisms.

4. Students will name the organs of human circulatory system.

5. Students will differentiate between open and closed types of circulatory systems.

6. Students will define double circulation giving atleast two examples.

7. Students will name the constituents of blood.

8. Students will recall that haemoglobine and haemocyanin are the two types of blood pigments.

9. Students will relate the type of blood pigment present in the blood and colour of the blood.

24

10. Students will recall the different functions performed by blood.

11. Students will recall the names of the tissues that help in translocation of food and other substances in plants.

12. Students will differentiate between the functions performed by xylem and phloem vessels.

13. Given the diagram of girdling in plants, students will reason out as to why food is collected above the girdling.

14. Students will reason out the importance of the haemoglobine to human beings.

15. Students will reason out the importance of platelets in the blood of human beings.

16. Students will reason out the importance of W.B.C. in the blood of human beings.

17. Given the information about an animal, students will reason out whether the animal has circulatory system or not.

18. Students will draw a diagram of human heart and label its parts.

25 Unit 6

1. Students will recall that every cell of a living organism requires energy to perform various metabolic activities.

2. Students will see the relationship between oxidation of food and burning of a candle.

3. Students will recall the definition of respiration.

4. Students will recall that glycolysis and Krebs cycle are the two major steps in respiration.

5. Students will recall that mitochondrias are the power houses of cells.

6. Students will differentiate between aerobic and anaerobic types of respiration.

7. Given the equations of aerobic and anaerobic respirations, students will see the relationship between the amount of heat evolved and the type of respiration.

8. Given the apparatus, students will write the procedure of the experiment to show that heat is evolved during aerobic respiration.

9. Students will infer that one of the waste products of respiration is carbon dioxide.

26 10. Given the procedure of the experiment, viz., carbon dioxide is produced during respiration, students will draw a neat sketch of the set up of the apparatus.

11. Students will recall that in lower organisms, exchange of gases takes place through the process of diffusion.

12. Given the different process of exchange of gases and the types of respiration, students will match them.

13. Given the information that an organism is not having special respiratory or circulatory system, students will reason out the nature of exchange of gases in that organism.

14. Given the table representing the composition of inhaled air and exhaled air, students will interpret the table.

15. Students will reason out as to why a fish placed in water which is boiled and cooled dies in a short time.

16. Students will predict the consequences, when a person is made to breathe in the same air which he has breathe out for a number of times.

17. Students will reason out asto why a person requires more food during winter than in summer.

27 18. Students will draw the diagram of human respiratory system and label the parts.

Unit 7

1. Students will recall that when proteins are oxidised, waste products like CO_2, H_2O, urea and uric acid are produced.

2. Students will recall that when sugars and fats are oxidised, waste products like CO_2, H_2O are produced.

3. Students will recall the definition of excretion.

4. Students will relate the nature of the waste product and the way it is removed.

5. Students will recall that nitrogenous substances produced during metabolic activities are thrown out in the form of urea, uric acid etc. in animals.

6. Students will recall the mode of removal of waste products in lower organisms.

7. Students will recall the different types of excretory organs found in animals.

8. Students will recall the different ways of removal of waste products in man.

28 9. Given various steps of the formation and removal of urine, students will rearrange them.

10. Students will draw a neat sketch of the cross section of human kidney and label its parts.

11. Students will recall the functions of skin, in human beings.

12. Students will reason out as to why plants do not have any special excretory organs as in animals.

13. Students will cite atleast 3 plants waste products which are useful to man.

14. Students will see the relationship in the process of removal of CO_2 by plants and animals.

15. Students will reason out as to why people drink lot of water during summer than in winter.

16. Students will give reasons as to why a person passes comparatively less amount of urine during summer than in winter.

17. Students will reason out as to why a person feels cool under a working electric fan.

18. Students will recall the composition of urine in human beings.

29 Unit 8

1. Students will recall the importance of water to all living organisms.

2. Students will recall the different forms of removal of water from the human body.

3. Students will recall the definition of transportation.

4. Students will recall that wilting in plants takes place due to excessive evaporation of water and less absorption of water from the roots.

5. Students will discriminate the important functions of skin from others.

6. Given the description about a plant, students will identify the habitat to which it belongs.

7. Students will see the relationship between the habitat of the plants and the corresponding modification in plants.

8. Students will reason out the different factors that affect transpiration.

9. Given the description about an animal, students will mention the habitat to which it belongs.

CHART XI

CHART SHOWING THE COMBINATION OF COMPONENTS UTILIZED FOR TEACHING DIFFERENT UNITS IN THE COURSE

Serial number of the unit	Title of the unit	Concepts dealt under the unit	Components utilized for teaching.(In their sequential order)
Unit 1	Importance of studying science	(a) Nature of scientific inquiry. (b) Contributions of scientists to the field of knowledge. (c) Advantages of scientific discoveries. (d) Misuse of scientific inventions.	Team teaching with more of students' participation.
Unit 2	Structure of a cell and its constituents	(a) Organs and systems in living organisms. (b) Cell as a basic unit of life. (c) Physical and chemical nature of protoplasm. (d) Organelles found in protoplasm and their functions. (e) Cell theory and its propounders.	Introduction by the teacher, teacher demonstrations, Programmed Learning Material, group activities, discussion, filmstrip with teacher's explanation, discussion, criterion test and feedback session.
Unit 3	Autotrophic Nutrition	(a) Concept of autotrophic nutrition. (b) Concept of photosynthesis. (c) Factors influencing photosynthesis. (d) Carbon cycle. (e) Gaseous exchange. (f) Chemosynthesis.	Introduction by the teacher, structured lecture, teacher's demonstrations with questioning, discussion, deviated Programmed Learning Material, discussion, criterion test and feedback session.
Unit 4	Heterotrophic Nutrition	(a) Concept of heterotrophic nutrition. (b) Different modes of heterotrophic nutrition. (c) Different types of ingestion of food. (d) Different types of digestion in animals. (e) Interdependence of animals and plants. (f) Food chain and ecosystem.	Introduction by the teacher, Programmed Learning Material, Students' activity, discussion, transparencies with teacher's explanation, deviated Programmed Learning Material, discussion, criterion test and feedback session.

Contd.....

Chart XI (Contd.)

Serial number of the unit	Title of the unit	Concepts dealt under the unit	Components utilized for teaching.(In their sequential order)
Unit 5	Transportation and circulation	(a) Concept of transportation. (b) Transportation in plants and animals. (c) Nature of circulation in animals. (d) Nature of blood and its functions.	Introduction by the teacher,transperencies integrated with teacher explanation,deviated Programmed Learning Material, students' activities, demonstrations with questioning techniques, criterion test and feedback session.
Unit 6	Respiration and production of energy	(a) Concept of respiration. (b) Types of respiration in plants. (c) Respiration in animals. (d) Mechanisms of respiration in animals. (e) End products of respiration.	Introduction by the teacher, deviated Programmed Learning Material with diagrams and students' activities, teacher's demonstrations, Programmed Learning Material, discussion, transperencies with teacher's explanation, discussion, criterion test and feedback session.
Unit 7	Excretion	(a) Concept of excretion. (b) Different forms of removal of waste products. (c) Mechanism of urine formation in human beings and role of kidneys. (d) Maintenance of water balance in the body.	Introduction by the teacher, deviated Programmed Learning Material with diagrams, students' activities, discussion, transperencies with teachers' explanation, discussion, criterion test and feedback session.
Unit 8	Water Economy	(a) Concept of water balance in living organisms. (b) Need for such a maintenance. (c) Modifications seen in organisms for this purpose. (d) Classification of the living organisms according to their habitat.	Introduction by the teacher, deviated Programmed Learning Material embedded with diagrams and students' activities, discussion and criterion test and feedback session.

30 DEVELOPMENT OF SOFTWARE MATERIAL TO BE PRESENTED THROUGH THE COMPONENTS IDENTIFIED FOR TEACHING DIFFERENT UNITS IN THE COURSE

Keeping in view the terminal behaviours specified for each unit, their sequence, and the structure of the content included in the unit, appropriate combination of components were arrived at for teaching each unit. Chart XI presents the combination of components utilized for teaching eight units of the course. Details regarding the development of software materials for the various components are presented in what follows.

Introduction by the Teacher

Every unit was introduced to students with a brief introduction to the whole unit. The idea behind providing such an information was to - lead students from known to unknown. In other words, through introduction attempts were made to link information about concepts presented in that particular unit with students' previous knowledge about those concepts. So that, the information in the unit would not be something totally new to students, on the other hand, would fit into their already existing cognitive structure. In this respect, it was thought that introduction to the unit would serve as 'Advanced Organizers' as proposed by Ausubel (1968). For developing software material for this component, the major concepts which the students would be coming across in different units were listed. The concepts

31 belonging to a particular unit were linked with each other and highlighted in the introduction to that unit. Through this, students were made known before hand as to what exactly they would be studying in that particular unit. This was done with the assumption that prior information about concepts which they would be studying in that unit would help them to understand the concepts better. Sometimes, certain questions have also been raised in the introduction. This was done with a view to generating curiosity in students, and thereby propelling them to think and seek answers to those questions.

In the introduction, at the end, it was also mentioned as to how they would be proceeding with the instructional material provided to them. This was done to facilitate students in the proper utilization of the instructional material. This brief introduction was provided to students in written form in the units which started with self-learning techniques, and orally in units which began with teacher's explanation. However, in such units also, where introduction was given orally, a point was made to supply students with introduction in written form, after teacher's explanation was over. Software material developed for this component have been presented in Vol.II of this report.

32 Programmed Learning Material (PLM) and Deviated PLM

PLM and Deviated PLM have been used to teach concepts which necessitated least interference by the teacher in enabling students to understand information about the concepts. Keeping in view the cognitive aspect of the terminal behaviours and the entering behaviours of the learners, either PLM or deviated PLM was developed. It may be mentioned that the nature of the subject matter (Biology) with its emphasis on observation has necessitated to bring in certain deviations in the format and style of presenting information under these components. Descriptions about the two instructional components are presented in the following, separately.

Programmed Learning Material:

In the PLM developed, the frames have been presented between horizontal lines, and the correct answers provided at the left hand margin of the succeeding frame. Students are expected to read each frame and write their answers in the blanks provided therein, after covering the given correct answer by a card distributed to them for that purpose.

So far as the style of PLM is concerned, throughout, it has been of 'Linear style'. Although, it is not a linear programme of the traditional Skinnerian type such as the one written by Holland and Skinner (1961). In the PLM developed, variations have been brought in with respect to size of the

33 frames, presentation of extra-frame material in-between frames, and in including diagrams in the frames. In these respects, it deviated from the conventional Skinnerian style of programmed learning material, wherein, size of the frames is very small. The size of the frame in the present PLM has been determined on the basis of the adequacy of the information presented through it about an idea or its aspects.

Frame Components:

Each frame in the PLM, including the correct answer, may be taken to consist of three parts. They are, a bit of information, a question in the form of blank and the correct answer provided immediately after the frame. However, in some frames, a diagram was also included to explain the idea contained in the frame better. This has been illustrated in the frame, viz., frame with a diagram.

Example 1 : A Typical Frame

Frame:

In the laboratory, you have observed onion peel under microscope. You might have noticed that onion peel is composed of a number of cells.

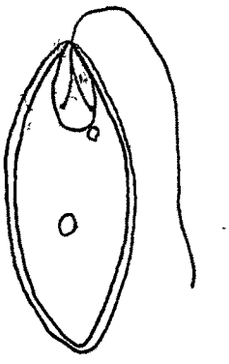
As onion is composed of a number of cells, it is not a _____ organism.

Correct Response - Unicellular

34 Example 2 : Frame with a Diagram

Frame:

See the diagram. It is the diagram of an organism known as Euglena. The entire organism is a small bit of protoplasm surrounded by a cell membrane. Hence, Euglena is also a_____celled animal.



EUGLENA

Correct Response - Single

Frame Structure:

The term 'frame structure' has been used to mean the specific types of questions intended in different frames of the programme. Programmes written in the traditional linear form, as the one by Holland and Skinner (1961), adopt completion type question as the uniform type of frame structure. The assumption made for using this type of frame structure uniformly is that students learn better if they have to construct their own answers instead of simply choosing the correct answer from a given set of answers. In the present PLM also completion type of frame structure is used uniformly throughout. An example in respect of this

35 frame structure is given below.

Example 3 : Completion Type of Frame Structure.

Frame:

Similarly, if you test for the presence of proteins in other plants also, you will find that all plant cells contain protein.

In other words, _____ is present in all plants.

Correct Response - Protein

Extra Frame Material :

In the course of the present PLM, one would frequently come across material presented in between frames. This material may be called as extra frame material. They have been introduced in the PLM with a view to either consolidate what students had studied in the earlier frames, or to provide additional information about the concepts, or to serve as a link to the next concept dealt in the succeeding frames. Examples in respect of these three different types of extra frame material used in the text are given below.

36 Example 4 : Extra Frame Material used for Summarising Frame

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Now let us try to summarise what we have studied so far. We have studied in the earlier frames about two types of association that exists among certain organisms, namely, paracitism and symbiosis. Paracitism is a harmful association that exists between two organisms, wherein, only one organism is benefited. Symbiosis is another type of association that exists between two organisms, wherein, both the organisms are benefited.

Example 5 : Extra Frame Material for Providing Additional Information.

Frame

In the earlier frames you studied about two examples of fats namely 'Stearin' and 'Oleic' acid. To cite a few other common examples, butter, ghee, vanaspathi, wax, milk cream, etc., are all fats.

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37 Example 6: Extra Frame Material used as Links.

Frame

So far we have tried to understand the chemical composition of proteins. You might recall that in addition to proteins, fats and carbohydrates, protoplasm of living organisms contain another organic compound, namely, nucleic acids. In the next few frames let us try to understand the chemical composition of nucleic acids.

Response mode:

Throughout the PLM, the mode of response has been kept as 'overt'. For each frame, the student has to indicate his response in writing. Then, he compares his answer with the correct answer provided immediately after the frame. He proceeds to the next frame if his answer is correct; but, if his answer is incorrect, he reads the previous frame/frames again, understands the point, and then proceeds further.

Frame size:

According to traditional Skinnerian PLM, the basic principle is to maintain the frame size as small as possible. In the present case, this has not been strictly followed. One would come across many large

38 frames. However, what needs to be mentioned is that in a frame only a single idea has been dealt with. In large frames, the additional information provided has been only to facilitate better understanding of the idea presented. As an illustration, a large frame taken from the text is presented below.

Example 7 : A Large Frame

Frame

Well, now you know two types of animals, namely, carnivorous and herbivorous animals. In addition to these categories, there is another category of animals which feed on both plants as well as animals. These animals are called as omnivorous animals.

Human beings, as you know, feed on both plant products as well animal products. Hence, they are _____ animals.

Correct Response - Omnivorous

Prompts:

Prompting is a basic technique employed in frame writing with a view to helping the students to arrive at the correct answer for the question posed in the frame. In the PLM developed in the

39 strategy, all the three kinds of prompts, namely, visual prompts, formal prompts and thematic prompts have been used considering their suitability in the particular learning situation. But a majority of the prompts have been visual and formal prompts. Examples in respect of the different types of prompts utilized in the PLM developed have been presented below.

Example 8 : Visual Prompt

Frame

In the earlier example, namely, bacteria living in the mouth and intestine of human beings, bacteria are called as parasites, since they obtain food directly from living organisms.

In the example of bacteria and human beings, human beings serve as hosts for the bacteria which are the _____.

Correct Response - Parasites

Example 9 : Formal Prompt

Frame

The difference between symbiosis and parasitism is, in symbiosis both the organisms are

40 benefit/ed, whereas, in parasitism only one organism is benefit/ed.

Parasitism differs from symbiosis, because, in parasitism only _____ organism is benefitted, whereas in symbiosis both the organisms are benefitted.

Correct
Response - One

Example 10 : Thematic Prompt

Frame

Recall what you observed about skin of potato, tomato and frog under the microscope. You have noticed that they are composed of more than one cell. Since, potato, tomato, frog, etc., are composed of more than one cell they are called as _____ organisms.

Correct
Response - Multicellular

Frame Sequence:

Another feature of programmed learning material is the sequential presentation of the information. Basically, two approaches of sequencing have been followed hitherto by the programme writers. They are 'Eg rule' and 'Rule eg'.

41 In the PLM developed in the strategy, 'Eg rule' approach, which promotes 'Inductive thinking' has been followed with a view to catering to the development of certain inquiry abilities in students like identifying the commonalities present in the different examples provided, arriving at the generalisation or 'rule' etc. However, at certain places in the PLM 'Rule eg' approach also has been utilized.

Types of Frames:

Three types of frames have been used in the PLM. They are teaching frames, practice frames and review frames. Teaching frames have been used to impart information, followed by practice frames as a sort of drill frames. At the end of the presentation of a concept/concepts, review frames have been presented to enable the students to review what they have studied about the concept of concepts till then. Examples in respect of these three types are presented below.

Example 11 : A Teaching Frame

Frame

Let us take one example of a protein present in wheat, namely, gliadin. It is composed of 685 atoms of carbon, 1068 aroms of hydrogen, 196 atoms of nitrogen, 211 atoms of oxygen and 5 aroms of sulphur.

42 From the above composition we can write the chemical formula for gliadin as_____.

Correct Response - $C_{685}H_{1058}N_{196}O_{211}S_5$

Example 12 : Practice Frame

Frame

The chemical composition of the protein 'Zein' are like this. It is composed of 736 aroms of carbon, 1161 atoms of hydrogen, 184 atoms of nitrogen, 208 atoms of oxygen and 3 atoms of sulphur.

If the chemical composition of protein 'Zein' is to be represented in the form of a formula, it would be _____.

Correct Response - $C_{736}H_{1161}N_{184}O_{208}S_3$

Example 13 : Review Frame

Frame

So far we tried to understand about the composition of different types of proteins.

We can say that proteins are_____

43 compounds, and are composed of atoms of_____

_____ _____ _____ and _____.

Correct
Response - Carbon, Hydrogen, Nitrogen, Oxygen, Sulphur.

The software material developed in respect of this component is presented in Vol.II of this report.

Deviated Programmed Learning Material:

Deviated PLM is another technique which has been introduced into the instructional strategy to impart basic information about certain concepts. Here the information related to a particular idea has been provided in the form of small paragraphs, with adequate illustrations through diagrams. After a few concepts being presented this way, questions pertaining to the concepts have been presented. The reasons for adopting such a technique (presenting information in small paragraphs) are the following.

While analysing the content, it was noticed that a few concepts in the course had been already dealt with in the earlier standards. It was thought that providing information about those concepts through small frames, may make the students feel bored to go through the frames. Further, since the students had studied those concepts in their previous standards, it was presumed that providing information relating to a particular idea illustrated with

44 appropriate diagrams may facilitate learning independently in less time. To facilitate this aspect, software material for this component was developed keeping in view certain considerations such as gradual approximation of concepts, questions to answer and also the correct answers to the questions for self-checking and feedback, which are generally considered essential for any self-learning technique. Software material developed in respect of this component is presented in Vol.II of this report.

Lecture Method:

Lecture method is another technique which has been utilized to impart basic information about certain concepts. Specifically, the concepts, teaching of which required more of teacher's explanation and interaction with the students. In this respect, it may be mentioned that the technique did not remain as lecture method in its traditional sense. The interaction aspect was facilitated by raising questions, seeking clarifications from the students, etc. Further, an effective treatment of these concepts required more explanation from the teacher — explaining with the help of charts, blackboard diagrams, models, experiments, etc.,and also, focussing students' attention on relevant points. Treating such concepts through self-learning ways may require more time and additional resources. Hence, keeping in view the amount of teacher's explanation needed, the time and the availability of other resources, lecture method

45 (Didactic expository method) was planned to teach certain concepts. To facilitate students' reference at home, information presented through this technique was supplied to students in written form after the exposition. Software material developed in respect of this component is presented in Vol.II of this report.

Team Teaching:

This technique has been utilized in the strategy with an objective to bringing home to students the interrelatedness of the three aspects of science, namely, Physics, Chemistry and Biology. More specifically, the objective behind utilizing such an approach had been to imbibe in students the fact that a single event or a phenomenon occurring in the environment will have more than an underlying concept or principle needed to understand it in its entirety. These concepts and principles may pertain to different aspects of the event or phenomenon, namely, the physical, chemical or biological. Hence, for developing an understanding of such an event or phenomenon in students, it becomes necessary to present learning experiences relating to these aspects of the phenomenon or event. Such exposures could be done through the technique of team teaching, wherein, two or more teachers (specialised in particular disciplines) would be presenting the information about a concept from different viewpoints, bringing in the interrelatedness of the information. In the present study, through content analysis, concepts which were

more prone to such a treatment were identified. The concepts such as nitrogen cycle and the mechanism of gaseous exchange in plants of the Unit III were taught through this technique. The physical and chemical aspects of these concepts were dealt by another investigator of the institutional project (referred to in Chapter II) who was developing material for physics and chemistry. The learning experiences were presented to students in the form of arguments, involving students often in the process of argumentation by raising questions, and arriving at particular conclusions. Cyclostyled handouts were supplied to students after the exposure. This was done to facilitate students in recalling specific aspects of the argumentation whenever they required. Software material in respect of this component is presented in Vol.II of this report.

Inquiry Technique:

The process of inquiry has been defined by various authors in various ways. In a narrow sense, it has been defined as a method of seeking answer through the systematic use of the scientific method. But a few who do not support this definition, define the term as 'whatever a scientist does to solve a problem'. Bruner (1961), a wellknown cognitive psychologist contends that through the process of discovery learning the students will have to explore examples in the environment and from them 'discover' the principles or concepts which are to be learned. While discussing the advantages of discovery learning, he stresses that teaching through

47 discovery method would enable students to increase their intellectual potency, imbibe abilities required for future discoveries and help the students in retaining and retrieving the information. To enable the students to undergo such an experience, questioning technique coupled with teacher demonstrations has been used in the strategy. Through questioning, students were propelled to generate hypotheses about certain scientific principles. By way of demonstration of experiments, students were given an opportunity to test these hypotheses. Software material in respect of this component is presented in Vol.II of this report.

Pupil Activities and Teacher's Demonstrations:

As already mentioned in the beginning of this section, a principle that was kept in mind while developing software material, was the principle of learning through performance. Learning of concepts in the discipline of science involves more of observation and perception of the phenomenon occurring in the environment and understanding it through its operation. To facilitate this, simple activities to explain the phenomenon were incorporated in the learning experiences. The nature of the activities have been such that students could perform them at home utilizing simple instruments or apparatus. Those experiments which required costly or not-easily-available equipments, were demonstrated to students. Pupil activities, sometimes, were organized in groups also

III

48

with the objective of developing in students the ability to work in groups cooperatively. Examples in respect of these can be found in the learning material presented in Vol.II of this report.

Discussion Sessions:

To bring in the aspect of human interaction, discussion sessions were organized. This component has been incorporated in the strategy with a view to achieving the following objectives:

1. to clarify the doubts encountered by students;
2. to develop in students certain higher cognitive abilities; and
3. to develop certain affect attributes like open-mindedness, tolerance, etc.

The discussion sessions were not unstructured as is usually the case at higher levels of education. Since the students were of the tender age, discussion sessions were structured with a view to assisting the students to imbibe the ability to discuss. At the following points in the process of instruction, slabs of discussion sessions have been organized in the strategy. They are:

1. after treating a few concepts,
2. after teacher's demonstrations,
3. at the completion of a unit.

It may be mentioned that the points for discussion were arrived at beforehand through content analysis. They were discussed at appropriate places. These points can be found in the learning material presented in Vol.II of this

49 report.

Audio-Visual Presentation:

Both projective aids (slides and transparencies) and non-projective aids (charts and models) accompanied by teacher's explanation have been used in the strategy with a view to making the concepts easily understandable to students. These aids have been used to teach such concepts as 'Organelles of a cell and their functions', 'process of digestion in animals', 'mechanism of respiration', etc.,in the strategy.

For preparing slides, first, diagrams were drawn on drawing sheets cut to the size of 10" x 6" with Indian ink. These diagrams were photographed. The film negatives were developed into 2" x 2" slides, and projected through the slide projector.

For preparing transparencies,diagrams were traced on cellophane paper in Indian ink. The transparencies were of the size of 8" x 10". In some transparencies,even colour was used to represent the parts distinctly. These transparencies were bordered on all the sides with hard cover paper strips, and were projected on screen using overhead projector.The projections were accompanied by teacher's explanation. After the presentations,a work-booklet was distributed to students.These work-booklets contained questions related to the points presented through projections. Further,to facilitate reviewing at home, students were supplied with cyclostyled copies of the entire presentation (both audio as well as visual), Diagrams

presented through slide and overhead projector along with teacher's explanation and also the workbooklets are presented in Vol.II of this report.

Historical Background of Scientists and Scientific Inventions:

It is a fact that many of the scientific inventions and discoveries, if not all, are because of scientists' wild guesses. Exposing students as to how certain scientists made wild guesses and how they thought about the problem from various angles would not only generate interest in students in the subject, but will also provoke students to think like scientists. Further, it is also a fact that science is not a finished product, but a process in itself of man's search for truth. Through incorporation of such information, it was thought to bring home to students the above facts and also to expose students to certain qualities like tolerance, patience, open-mindedness, curiosity etc., (scientific attitude) which scientists exhibited in their pursuit of knowledge. Software material in respect of this component is presented in Vol.II of this report.

Summaries:

Structured summaries were provided at two places in the course of an instructional unit. One, at the end of the completion of the unit. This has been provided with a view to helping the students to get an overall picture of what

51 they had studied in that particular unit, and also to facilitate quick revision at the time of tests and examinations. Second point at which summaries have been incorporated is at the end of completion of a few concepts in a unit. This has been done with a view to establishing and retaining the link which is necessary, especially, when an instructional unit includes a number of concepts. To retain the positive aspect of teacher involvement, these summaries were first discussed in the class, eventhough they were provided to students along with the instructional materials, specially the self-learning material. Software in respect of this component can be seen at appropriate places in the learning material presented in Vol. II of this report.

Criterion Tests and Feedback:

To ensure the outcome of the strategy in terms of students' achievement, criterion tests (unit tests and comprehensive tests) were developed. A criterion test is one that determines the extent to which the terminal behaviours are attained. Unlike a norm-reference test, its objective is not to discriminate between high and low achievers but to detect steps arrived at by each student, where he has failed, whether he has acquired the terminal behaviour or not. Hence, in a criterion test the main consideration would be the relevance of the items to the termal behaviours specified. In the present investigation, in all, seven unit tests were developed for units 2 to 8. As the first unit was only an

52 orientation unit, no unit test was developed. These tests were developed simultaneously along with the listing of the terminal behaviours. Since these tests were developed in accordance with the terminal behaviours, achievement on the criterion tests would indicate the extent of attainment of terminal behaviours. The questions in the unit tests were mainly of multiple choice and short answer type, and catered to four categories of objectives, viz., knowledge, understanding, application and skill. It may be mentioned that all the unit tests contained questions related to knowledge, understanding and application objectives. Only unit tests 6 and 7 contained items related to skill. The scheme of categorisation of the objectives for measurement purposes is in accordance with the Advanced Curriculum Model of Cognitive Learning (ACMCL) developed by Dave, et al. (1974). It is an empirically validated theoretical frame work or model for classifying evaluation goals under cognitive domain. In this model, the evaluation goals have been classified into 4 categories, viz., knowledge, understanding, application and creativity. In addition to unit tests, two comprehensive tests were also developed. Comprehensive Test-I was comprehensive of Units 2, 3, 4 and 5. Comprehensive Test-II covered Units 6. 7 and 8. Both the comprehensive tests included representative samples of items related to the 4 categories of objectives, viz., knowledge, understanding, application and skill. The questions in the tests were mainly of the type multiple choice and short answer. The developed unit tests and

53 comprehensive tests have been provided in Appendix-A.

Besides contributing towards validation of the strategy and providing necessary information for reappraisal and modification of the instructional material, criterion tests can also serve as a valid instructional component in providing students with the opportunity to self-evaluate or self-check. To provide necessary feedback, students' performance on unit tests were analysed to study the areas of misconception. These points were noted and clarified to students in regular classroom sessions. Provision for individual feedback was also made available to students whenever they sought for it. Besides providing necessary feedback to students, these sessions were also utilized to collect reactions of students towards various components utilized for teaching that particular unit, since they were to be analysed and studied for improving the instructional material. These feedback sessions have contributed to the strategy by bringing in yet another opportunity for human interaction, thereby, retaining the positive aspects of teacher involvement.

Exercises and Assignments:

Research studies (Briggs, 1968) have shown that drill and practice are useful in solidifying, improving and reinforcing what is learnt. Practice is same as drill, except tnat the word drill connotes meaningless teacher conducted

54 repetition, and practice refers to more thoughtful, largely self-directed repetition. In the strategy, this has been provided to students in the form of exercises and assignments. They have been incorporated in the strategy at various points. As a feedback, correct answers were provided after the exercises, so that students could check their answers with the correct answers. Sometimes, exercises have been given in the form of assignments, which required students to collect information relating to a particular concept from different books, or to draw a diagram from an advanced book. It may be mentioned that sequencing of these components in the instructional strategy has been shown by inserting them at appropriate places in the learning material itself.

The software material developed for various components were examined by content and methodology experts for their appropriateness. In the light of the comments of the experts, the material was modified. The material was to be made ready for the final tryout. How this has been done in the study is explained under the next heading 'Tryout'.

Tryout:

The initial tryout was done during the year 1976-77 on a group of 45 VIII std. English medium students. These students belonged to one section of the school, viz., Shreyas Vidyalaya, Baroda; the school where the final

55 administration of the strategy was carried out. During this stage of initial tryout, developed software material in a few units for the components such as PLM, Deviated PLM, Audio-visual presentations were administered to assess language suitability, smooth flow of content matter, and for feasibility aspects. Along with these, with regard to other components too, e.g., discussion, team teaching, etc., tryout was done to ascertain how these components would function without introducing major changes in the actual classroom situations. The tryout also provided an insight as to how the various components could be sequenced to function effectively.

In the light of the experience gained, the software material for different components were suitably modified, and thus made ready for the final tryout.

Besides the development of software to be presented through various components, a need was also there to develop necessary tools for measurement purposes. Details regarding the development of these tools are presented in what follows under the heading 'Instrumentation'.

INSTRUMENTATION

It may be recalled from what has been presented under 'design' that validation of the strategy has been done in terms of students' performance on different achievement tests, students' gain on Scientific Attitude Test

56 (pre-test to post-test) and also through their reactions towards the working of the individual components of the strategy and the strategy as a whole. To realize this aspect of the objective, tools such as achievement tests, Scientific Attitude Test, and a reaction questionnaire were developed and utilized. Details pertaining to these tools have been presented below:

Achievement Tests:

Two types of achievement tests have been utilized for validating the strategy in terms of students' achievement. One, unit tests and comprehensive tests developed by the investigator; and two, an annual examination developed by the school authorities for promoting the students to the next standard. Details pertaining to the development of unit tests and comprehensive tests have already been given under the heading 'Development of software material to be presented through the components identified for teaching different units in the course'.

Annual Examination: A question paper for the annual examination was developed by the school authorities in consultation with the investigator for promoting students to the next standard. It covered Physics, Chemistry and Biology portions. The questions included under Biology section were comprehensive of the units 2, 3, 4 and 5. The questions were mainly of the type essay, short answer and

57 multiple choice. The Biology section of the annual examination is presented in Appendix-A.

Scientific Attitude Test:

This test was used in the investigation for validating the strategy in terms of development of scientific attitude in students. Since no standardized test (standardized on Indian sample) for measuring scientific attitude was available, a test for the same was developed. Details pertaining to its development and psychometric properties are presented in what follows.

Attitude and its Measurement:

A term, which has received considerable attention regarding its conceptualisation and measurement by the social scientists, is 'attitude'. Derived from the Latin word 'aptus', it signifies 'fitness' or 'adaptedness' and connotes action. An examination of the literature on attitudes reveal that it is replete with many and varied connotations and its similarity with or difference from other related concepts like opinion, habit, belief, value, ideology, etc. In general, attitudes have been considered as mediating variables, and hence it has been argued that they cannot be measured ~~from~~ directly and must be inferred from some overt response (Lemon, 1973; FishBein, 1967). Obtaining a measure of respondent's agreement or disagreement with a set of opinion statements about the attitudinal

58 object or situation is the most widely used approach. The consideration made in the present attempt is that since attitudes are considered as predispositions to some preferred response, probably, a reasonable approach to attitude measurement is to draw inferences about an individual's attitude from his endorsement, or lack of it, of various courses of action in certain situations which are relevant to the attitudinal object or situation. This is in line with the position taken by Kozlow and Nay (1976).

Operational Definition of the Construct 'Scientific Attitude':

To arrive at the operational definition of the construct, literature related to scientific attitude were consulted. A perusal of the literature related to scientific attitude reveal that in the past few decades, several attempts have been made by researchers to define the term 'Scientific Attitude' and construct instruments for measuring it. The works of Curtis (1924); Noll (1935); Ebel (1938); Klopfer and Cooley (1961); Haney (1964); Diedrich (1967); Moore and Sutman (1970); Billeh and Zakhariades (1975); Kozlow and Nay (1976) are in this direction. On the Indian scene too a few workers in the field of science teaching have attempted to describe scientific attitude, Vaidya (1976), Pritam Singh (1977) and Arunkumar and Menon (1978). If one goes through the works of these authors, what could be observed as a commonality is that almost all the authors

59 have defined the construct scientific attitude in terms of components, described by related behaviours. However, variation could be noticed as regards the totality of the components identified and the categories of behaviours envisioned as belonging to a particular component. To illustrate this point, the scientific attitude scales developed by Billeh and Zakhariades (1975) and of Kozlow and Nay (1976) could be considered. In the scale developed by Billeh and Zakhariades (1975), under the component 'suspended judgment' are included behaviours such as unwillingness to draw inferences before evidence is collected, unwillingness to accept as facts things that are not supported by convincing proof and avoidance of quick judgments and jumping to conclusions, whereas, Kozlow and Nay (1976) include in their scale behaviours such as generalises only to the degree justifies by available evidence, collects as much data as possible before drawing conclusions, recognizes conclusions as being tentative, consulting several authorities (texts, periodicals, people) before drawing conclusions, under the same component. Besides, one can also notice variation with regard to certain behaviours being labelled as a component by one author, whereas, it is being given only a cursory attention by another author as one of the behaviours under a component. To cite an example, Billeh and Zakhariades (1975) include the behaviour seeking for natural causes of events and identification of cause-and-effect relationships under the component 'Rationality', whereas, the same behaviour is

given the status of an individual component by Pritam Singh (1977). However, a description of scientific attitude in a comprehensive manner is given in the Forty-sixth Year Book of the National Society for the Study of Education and in the works of Harris (1960) and Pritam Singh (1977).

As a preliminary step to arrive at the components of scientific attitude, the lists of behaviours as enumerated by various authors (foreign as well as India) were critically examined for the distinctiveness or overlap of different behaviours, if any. The investigator held discussions with a few experts from CASE, M.S.University of Baroda,Baroda, and as an outcome it was concurred that the different behaviours related to scientific attitude could be conveniently described under eight major components which would constitute the construct 'Scientific Attitude'. In this process of arriving at eight components, a few of the behaviours enumerated by the earlier workers in the area, were logically considered to be subsumed under particular components. The eight components thus arrived at are listed hereunder:

(1) Empiricism
(2) Curiosity
(3) Freedom from bias
(4) Open-mindedness
(5) Criticality
(6) Intellectual honesty
(7) Seeking evidence
(8) Observation.

After arriving at the components, the related exercise was to list the behaviours through which the

components of the scientific attitude could be described. The behaviours listed for each component were examined by experts for their adequacy in explaining the particular component and also for any overlapping. The final list of behaviours arrived at for each component through these discussions, have been presented below.

1. Empiricism:

belief in cause-effect relationship;
aversion to superstition;
commitment to rationality.

2. Curiosity:

tendency to know more about events, objects;
phenomena which cannot be explained by the existing knowledge;
asks questions;
reads to find information;
initiates and carries out investigations; and
inclination to observe.

3. Freedom from Bias:

respect for facts;
freedom from emotional attachment to selective ideas, beliefs, etc.

62

4. Open-mindedness:

respecting others' points of view;

willingness to change opinions on getting evidence to the contrary;

considering several possible options while investigating problems.

5. Criticality:

analyses various aspects of a problem or situation;

reflects on observations;

looks for inconsistencies in statements and conclusions; and

challenges the validity of unsupported statements.

6. Intellectual Honesty:

reports observations even when they contradict his hypothesis;

acknowledges work done by others.

7. Seeking Evidence:

does not jump to conclusions;

does not accept statements as facts without sufficient proof;

does not believe in the principle of authority unreflectively;

generalises only to the degree justified by available evidence;

recognises conclusions as being tentative.

8. Observation

63

precision in observation; and

detailed observation.

Having arrived at the components and the behaviours through which the components could be described, the next step was to construct test items, performance on which would indicate the attainment of this attribute. At this stage, the nature of the format of the instrument was to be decided.

Test Format:

Literature on attitude measurement is replete with several modes of approaches of measuring them. However, most commonly adopted modes have been those of Thurstone, Likert and Semantic differential of Bogardus. Other modes used are questionnaires, interview schedules, observation schedules, sentence completion, word association, etc. Each of the above has its own merits, demerits and limitations. They have been highlighted by Lemon (1973). For an examiner of these different approaches, Thurstone scales appeal to a greater extent than the others, since he has, in his model, put forth a sound theoretical and mathematical foundation to support the analytical procedures used for the calculation of scale values. However, on a closer scrutiny of the Thurstone's model, it becomes apparent that he has assumed a unidimensional attitudinal object. This assumption requires development of a large number of scales for identifying all

64 of the dimensions of the affective domain in science instruction. In this respect, Kozlow and Nay (1976) have rightly stated that 'since a considerable amount of work is required on the part of respondents who provide the data from which the scale is to be determined, the construction of a large number of scales may not be a practical undertaking'. As the test was to be administered on students belonging to tender age (14 years and below), Likert scales were considered inappropriate since the pointwise scale showing degrees like "strongly agree", "agree", "undecided", "disagree" and "strongly disagree" may not be easily discriminated by the respondents. Further, both Likert and semantic differential scales suffer from a major limitation, that is, the possibility of response bias on the part of the respondents. For example, the tendency on the part of respondents to choose the extremes. Keeping in view the merits and limitations of the different techniques of attitude measurement and the consideration made in the attempt, viz., 'attitudes are predispositions to some preferred response, and can be inferred from one's endorsement, or lack of it, of various courses of action in certain situations which are relevant to the attitudinal object or situation', it was decided to use multiple choice type of itemsfor measuring scientific attitude. The appropriateness of this technique lies in its simplicity. That is, through the stem of an item, a problematic situation could be exposed to the respondents, which would be followed by distractors describing different

65 courses of action. In the process of responding to the test, the respondent would read the stem of each item and the alternatives provided, decide which one among the alternatives would be his most frequent response and indicate it by encircling the appropriate number that is prefixed against the alternative. In the present attempt, multiple choice items included a stem describing a situation relevant to a component of the scientific attitude and the distractors describing different courses of action. However, a deviation was made for considering the type of items related to the component observation. Since the listed behaviours for the component were preciseness and detailed observation, items of the following types were considered relevant. One, items requiring a comparison of pictures apparently similar but which could be differentiated on closer examination. Two, items containing a passage in English which was followed by a copy of the same but with a few errors deliberately made, which the respondent can figure out on keen observation and comparison. Three, pictures requiring the respondent to list all the observations he could possibly make on them.

Writing and Selection of Items:

With the listing of behaviours for each component of scientific attitude and deciding upon the format of the test, the next step was to write and select appropriate items to constitute the test. In all, 80 items were written, which constituted the initial pool of items. Each item had

66 three alternatives representing least, moderate and most scientificity. This initial pool of items were scrutinized by experts to judge the representation of daily life situations within the familiarity of the students of the target group, to study the representation of behaviours denoted under each component and the degree of scientificity among alternatives provided for each item, to see that the stem of the items describing the situations do not suggest the respondent to opt for a particular alternative and the items were free from science content. Lastly, the items were also examined for language suitability, ambiguity of words used, length of the stem and alternatives.

The critical examination of the initial pool of items by the experts yielded a total of 50 items. The exact distribution of these 50 items in respect of different components is presented in the Table 3.1.

The decision to have only these few items under each component, was made due to the consideration that having more items sampled for each component would make the test unduly long, and would be more demanding on the respondent's part. Care was taken to see that the items belonging to a particular component were distributed across the test. Also, the order of presentation of the alternatives under each item, representing different degrees of scientificity, was varied across the items. These steps were taken to eliminate patterned responses which might result if all the items

67

TABLE 3.1

Table Indicating Distribution of 50 Items in Respect of 8 Components of Scientific Attitude

Sl. No.	Name of the component	Number of items
1.	Empiricism	6
2.	Curiosity -dom	6
3.	Free from bias	6
4.	Open-mindedness	6
5.	Criticality	6
6.	Intellectual honesty	7
7.	Seeking evidence	7
8.	Observation	6

belonging to a particular component were concentrated at one point in the test, or, if the alternatives were presented in the same order for each item. This initial format was made complete by providing a section preceding the items, wherein, relevant information regarding the respondent was sought and necessary directions to respond to the test and an illustration of performance on items were provided. The initial format is presented in Appendix-B. How this initial format was tried out for selecting items for the final format, is given under the heading 'Tryout of the initial format'.

Tryout of the Initial Format:

Sample: The sample for trying out the initial

68 format constituted of 80 students selected from two English medium secondary schools of Baroda city. However, for the purpose of item selection only 70 students were considered, since the rest 10 students did not complete the test in all respects. It may be mentioned that the school where multimedia strategy was to be implemented was not considered for this tryout. This was done with a view to avoiding any diffusion of information about the test. In this connection, it may be mentioned that the schools selected for tryout of the initial format were at a sufficiently far of distance (minimum of 4 Km.) from the school where the strategy was to be implemented. Description of the sample chosen for the tryout of the initial format of the test is presented in the Table 3.2.

TABLE 3.2

Description of Sample of Students considered for the Tryout of the Initial Format

Sl. No.	Name of the school	Total No.of students responding	No.of students responses considered	Total
1.	Rosary High School, Baroda	48	46	46
2.	Vidya Kunj High School, Baroda	32	24	24

Administration of the Initial Format: The test, along with the necessary directions, was administered on the

69 sample referred to earlier, during the year 1978. Administration was carried out in both the schools on the same day. Students were allowed adequate time to complete all the items. The responses thus collected on the initial format were scored for item analysis and selection. The scoring procedure adopted is given in what follows.

Scoring Procedure:

As has been mentioned earlier, the response alternatives represented three degrees of scientificity, namely, least, moderate and most scientific. These alternatives were assigned the scores of 0, 1, and 2 respectively. Thus the maximum score attainable on the test was 100 and the minimum score would be zero. The values 0, 1 and 2 are only ascriptions necessitated strictly from the formal measurement point of view. However, it is presumed in the present attempt that there would be a certain degree of scientificity in every individual respondent, and that scientific attitude is a composite of behaviours, the situation wherein any individual getting a score of zero on the total test may not arise. In the case of items developed for 'observation' component, the scoring procedure was formulated as follows: The total number of observations expected in respect of each item was determined. This was divided into three equidistant cut-off points, that is, for a maximum of 18 observations, the points representing the degrees of scientificity were 1-6 least scientific, 7-12 moderately

70 scientific and above 12 most scientific, and these were assigned the scores of 0, 1 and 2 respectively.

Item Analysis and Selection of Items:

As mentioned earlier, the responses of the students on the initial format were scored with the scoring procedure 0, 1 and 2; the values 0, 1 and 2 representing least, moderate and most scientificity respectively. Likert's method of summated ratings was used for item analysis and selection. This method was adopted due to the following considerations. As in Likert's scale, the present test too does not have a neutral point. Also, the interest in the attempt was not to judge an individual on the basis of his attitude score as being highly scientific or least scientific, on the other hand, the attempt was to determine the change in attitude score of the group after exposure to the instructional strategy. Besides, other methods of item analysis like correlational methods do not result in higher accuracy in selection of items. There is evidence to show (Murphy and Likert, 1934) that the rank ordering of statements upon the basis of the magnitude of the differences between the means of high and low groups agree very well with the ordering of the same statements in terms of the magnitude of the correlation between item response and the total score. In the light of the above considerations, as a simple and convenient procedure, the difference between the means of high and low groups on the individual test item as a basis

for selecting items for the final format was adopted. The summated scores of the 70 respondents on a frequency distribution is indicated in the Table 3.3.

TABLE 3.3

Frequency Distribution of 70 Scores on Scientific Attitude Test

Class interval	89-91	86-88	83-85	80-82	77-79	74-76	71-73	68-70	65-67	62-64	59-61	56-58
Frequency	1	3	6	10	13	9	17	3	2	3	2	1

The item analysis procedure demanded that high and low groups be formed on the basis of the summated score. The seventy summated scores obtained were arranged in descending order. From this distribution, the upper 25 and the lower 25 scores were selected to constitute the high and low groups respectively. For each item, 't' value was computed using the standard 't' formula. The obtained 't' values were grouped according to the components to which they belonged. They were placed in descending order of 't' values under each components. The 't' values arranged in this manner are presented in the Table 3.4. The items which were selected to constitute the final format of the instrument are also indicated in the table by asterik marks, the criterion for selection being that the 't' values obtained be greater than 1.75 (Likert, 1932).

72

TABLE 3.4

Componentwise Presentation of 't' Values of Items

Sl. No.	Component	Item No.	't' value
1.	Empiricism	3	2.829*
		23	2.754*
		34	2.080*
		13	1.158
		2	0.876
		6	-1.000
2.	Curiosity	28	3.554*
		39	3.474*
		36	3.329*
		16	2.685
		8	1.200
		1	0.651
3.	Freedom from bias	27	2.280*
		15	2.198*
		22	1.737*
		41	1.654
		9	0.000
		31	-0.316
4.	Open-mindedness	26	2.489*
		30	2.311*
		35	2.139*
		18	2.080
		43	1.610
		11	1.000
5.	Criticality	24	3.460*
		32	3.361*
		40	3.289*
		37	1.163
		7	0.731
		20	0.582

Contd.....

TABLE 3.4 (Contd.)

73

Sl. No.	Component	Item No.	't' value
6.	Intellectual Honesty	42	3.395*
		17	2.192*
		19	1.447*
		44	1.415
		33	1.042
		10	1.000
		25	0.207
7.	Seeking Evidence	29	2.803*
		14	2.000*
		12	1.670*
		5	1.260
		38	0.975
		4	0.766
		21	0.000
8.	Observation	46	2.450*
		50	1.971*
		48	1.753
		45	1.701*
		49	1.336
		47	0.602

* indicate the item selected for the final format.

It may be noticed from the Table 3.4 that three items, namely, 19, 22, 12 and 45 belonging to the components "intellectual honesty", "freedom from bias", "seeking evidence" and "observation" respectively, have 't' values less than the criterion value 1.75. Since three items satisfying the criterion value of 1.75 were available in respect of most of the components, it was decided to accommodate the items referred earlier in the test, eventhough they fell short of the criterion value. Discretion was used for the

74

inclusion of these items in the final format by examining the items and modifying them suitably. It may be of interest to note that in respect of the observation component, the item number 45 having a lower 't' value than item number 48 has been selected. This was done with a view to ensuring representativeness of variety in observation items.

The Final Format:

Through the process of item analysis and selection described earlier, the final format of the test was arrived at. It consisted of a total of 24 items; 3 representing each component with the scoring procedure remaining 0, 1 and 2 respectively for least scientific, moderately scientific and most scientific responses. The final format of the test is presented in Appendix-B.

Reliability and Validity of the Test:

For establishing reliability of the final format of the test, data obtained on its administration (pre-test and post-test data) on the sample considered for validating the strategy in terms of students' gain on scientific attitude were used. In all, 6 sets of data were used. They have been represented below:

75

1. Pre-test scores - Experimental group
2. Post-test scores - Experimental group
3. Pre-test scores - Control group 1
4. Post-test scores - Control group 1
5. Combined Pre-test scores - Experimental and Control group 1
6. Combined Post-test scores - Experimental and Control group 1

Details regarding the sample and administration of the final format of the test have been presented in Section II of this Chapter.

Reliability: The internal consistency reliability of the test was estimated using Cronbach alpha coefficient. The formula is given hereunder:

$$\alpha = \left(\frac{n}{n-1}\right)\left(1 - \frac{\Sigma Vi}{Vt}\right) \quad \text{.... Guilford (1954)}$$

Where: Vi = Variance of part 1 of a test, the size not specified.

Vt = Variance of total scores.

n = number of parts.

In the present attempt, each item was considered as a part, thus, yielding 24 parts. For each set (group) of scores, the variance of the total test, the sum of individual variances of the parts and 'α' values were computed. Thus, 6 estimates of internal consistency reliability were obtained for the 6 sets of scores. They are presented in Table 3.5.

76

TABLE 3.5

'K' Values for the Six Sets of Scores

Sl. No.	Test	Vt	ΣVi	'K' value
1.	Pre-test (Experimental group)	4.920	10.85	0.572
2.	Post-test (Experimental group)	5.610	8.95	0.745
3.	Pre-test (Control group 1)	4.590	10.21	0.536
4.	Post-Test(Control group 1)	6.404	10.95	0.762
5.	Pre-test (Experimental + Control group)	23.91	10.67	0.576
6.	Post-test (Experimental + Control group)	37.82	10.03	0.764

It may be observed from Table 3.5 that the internal consistency values range from 0.536 to 0.764 in each of the combinations of pre-test and post-test. It may be recalled from what has been discussed under 'Item analysis and selection of items' that the performance of students on the test was to serve as an index of the treatment (instructional strategy) given. Hence, the emphasis is on the group's performance as a whole rather than in making finer discriminations among individuals on the test. In such situations, as it has been pointed out by Whitefield (1970), the values of reliability of the above range are quite satisfactory. Also, it may be remembered that the test consisted of only 24 items; 3 items each for the eight components that constituted

77

the construct 'Scientific Attitude'. Since, internal consistency increases with the length of the test, it may sometimes necessitate reconciliation to smaller reliabilities resulting due to making tests of manageable size (Webster, 1957). In the light of the above remarks, it may be concluded that the reliability of the test is satisfactory, and perhaps, could be seen for its enhancement by administering the test on a larger sample.

Validity: The test has been examined for its logical validity. Logical validity requires a careful definition in behavioural terms of the trait or the construct to be measured. It also involves a breakdown of the total area defined into categories which represent all major aspects of the area (Helmstadter, 1964). Logical validity of the present instrument can be argued on the basis that the components of the attitude which the test is designed to measure were selected from a list of affect attributes of scientists; the behavioural specifications of these components were selected on the basis of responses of a group of experts and the themes of the items are comparable with the ideas expressed in a wide variety of science reading material. The validity of the alternatives has been demonstrated by a group of experts.

Reaction Questionnaire:

Students' reactions towards working of the individual

78. components of the strategy and the strategy as a whole, were obtained through unstructured interviews and a reaction questionnaire. In the beginning, it was thought appropriate to have only interviews with the students for obtaining reactions, since the subjects were of tender age and may find responding to a questionnaire boring. It was also thought that through building necessary rapport and through certain probing questions, necessary free and frank reactions towards the working of the various components and the strategy as a whole could be elicited. However, the need for developing a reaction questionnaire was necessitated due to the reason that it was not possible to hold interviews with all the students who comprised the sample.

For developing the reaction questionnaire, each component that comprised the strategy was analysed in terms of its potentialities in enhancing learning. Specific questions pertaining to the structural characteristics of the components were framed. These questions constituted the reaction questionnaire. The questionnaire was examined by content and methodology experts for the adequacy and suitability of the questions asked. In the light of the comments offered by the experts, the reaction questionnaire was modified. It comprised of both open-ended and closed type of questions. To allow sufficient scope for the students to give their suggestions for improvement, an

79 item for suggestions was included under each component. The developed questionnaire has been presented in Appendix-C.

With the instructional material and measuring instruments ready, the next step was to administer them on the target population and study the effectiveness of the strategy. Details pertaining to the validation of the strategy has been presented in the section to follow.

SECTION II

VALIDATION OF THE MULTIMEDIA INSTRUCTIONAL STRATEGY

In any instructional system development, evaluation forms an integral part. It forms an integral part in the sense that it is included as a necessary step during and at the completion of every phase of 'System development'.Evaluation as an integral part of the instructional strategy development, offers empirical evidences to the aspects such as effectiveness of each component constituting the strategy as well as the strategy as a whole in achieving the set objectives, suitability of the strategy to the group, feasibility of the strategy in terms of time and cost, and the modifications required for the efficient functioning of the strategy. Approaches of evaluation adopted in evaluating instructional strategies or programmes can be distinguished as internal validation and external validation. In the process of internal validation, the attempt is to test how well the strategy attains the objective it is intended to attain. As regards external validation, the aim is to validate the strategy against an external criterion. Both the approaches of validation have been employed in the present study. It may be recalled from the 'design' presented in the earlier section that validation of the strategy has been done in terms of three criteria, namely, students' performance on

2 unit tests and comprehensive tests, gain on Scientific Attitude Test, and reactions towards working of the individual components of the strategy, and the strategy as a whole. Details pertaining to validation of the strategy are presented hereunder.

SAMPLE

For validating the strategy in terms of students' achievement, four groups of std. VIII students belonging to one of the English medium schools of Baroda, namely, Shreyas Vidyalaya, were considered. Of the four groups considered, two groups belonged to the academic year 1977-78, and the other two groups to the academic year 1978-79. The strategy was implemented on a group of 45 students belonging to the academic year 1978-79.

In the beginning of the academic year 1978-79, there were 83 students in std. VIII. For the purpose of experimentation, this total of 83 students was to be divided into two groups, namely, experimental group and control group. To form these groups, needed permission was sought from the school authorities. As the strategy was concerned with teaching of science, to avoid concentration of students belonging to a particular level of achievement in the subject-science in any one of the groups, the total of 83 students was divided into two matched groups consisting of 42 and 41 students each. The variable considered for matching was students' performance on VII std. science examination. The

3 groups were matched for their means and S.D.s. Of the two groups thus formed, one was randomly selected for implementing the instructional strategy. This group is denoted as experimental group and it comprised of 42 students. The other group not exposed to the strategy is denoted as control group 1. However, 7 more students were admitted after the formation of the groups. These students were assigned randomly to the two groups; 3 and 4 respectively to the experimental group and the control group 1.

Besides experimental group and control group 1, as mentioned in the beginning, two more groups of the academic year 1977-78 have also been considered for validating the strategy in terms of students' achievement. These two groups are referred to as control group 2 and control group 3, and consisted of 45 and 47 students respectively.

For validating the strategy in terms of students' gain on scientific attitude test, all the 90 students belonging to experimental group and control group 1 constituted the sample.

As regards the validation of the strategy in terms of students' reactions, all the 45 students of the experimental group constituted the sample, since it was the only group which was exposed to the strategy. Of these 45 students, 15 students were selected for the purpose of holding interviews regarding the working of the strategy and the different components. For selecting these 15 students, the

4 total of 45 students was divided into 3 groups, namely, high, average and low achievers on the basis of their general trend in performance on criterion tests. From each group, 5 students were selected randomly using table of random numbers. The rest 30 students were considered for administering the reaction questionnaire.

IMPLEMENTATION OF THE MULTIMEDIA INSTRUCTIONAL STRATEGY

The instructional strategy developed through the initial tryout was implemented on the experimental group in the year 1978-79. Implementation began with the first unit, namely, 'Importance of studying science'. This was taught through a team approach. Through this unit, it was made known to students as to how they would be studying science that year. Since this was just an orientation unit, no criterion test was administered to ascertain the learning outcomes. This unit was followed by the teaching of the rest of the units. Each unit was introduced through a brief introduction. The concepts in each unit were taught through the different components selected (refer Chart XI, page No. 108 for the components utilized for teaching different units). After teaching a few concepts in each unit, discussion sessions were organized to clarify students doubts, and also to give them an opportunity to exchange their views on the concepts learnt. At the end of the unit also discussion sessions were organized to enable the students to review what they had

studied in that unit. This was followed by the administration of the unit test. Unit tests were scored and students' performance on the test was discussed. This discussion was mainly to give feedback to students and to provide further clarifications to the concepts where they had gone wrong as revealed by the unit test. This way, all the units in the course were taught. It may be mentioned that by the close of the academic year 1978-79, due to certain organizational constraints, only 4 units (units 2, 3, 4 and 5) were covered. At the end of the academic year 1978-79, comprehensive test-I was administered. This test was also administered to all the three control groups. To control group 1, it was administered along with the experimental group. As regards control groups 2 and 3, it was administered at the end of the academic year 1977-78.

The rest of the units (units 6, 7 and 8) along with their respective unit tests were taught in the beginning three months of the subsequent academic year, i.e., 1979-80 to the same batch of students in std. IX. For this purpose, the school authorities were requested not to start the regular IX std. science programme till the completion of the VIII std. science portion. After teaching the units 6, 7 and 8, comprehensive test-II was administered. This test was administered in the month of August, 1979.

Besides the above unit tests and comprehensive tests, the annual examination was conducted by the school

6

authorities during the implementation of the strategy. It was conducted for both the experimental and the control group 1 at the close of the academic year 1978-79. This examination was intended to promoting students to the next standard. The test was same for both the groups, and it included the content covered till that point of time. It may be mentioned that the units taught in both the groups were same, i.e., units 2, 3, 4 and 5.

As regards administration of scientific attitude test, it was administered at the beginning of the academic year 1978-79 to both the experimental group and the control group 1 as pre-test, and as post-test at the end of the same academic year.

For obtaining students' reactions towards the individual components of the strategy and the strategy as a whole, at the end of the academic year 1978-79, interviews were held with the fifteen students selected for this purpose. The rest of the students were administered reaction questionnaire.

Thus, the data needed for validating the strategy in terms of students' achievement, their gain on scientific attitude test, and reactions towards the individual components of the strategy and the strategy as a whole were collected. The data collected included (a) experimental group students' performance scores on unit tests and comprehensive tests; (b) control groups 1, 2 and 3 students' performance

7 scores on comprehensive test-I; (c) experimental group and control group 1 students' performance scores on the annual examination conducted by the school authorities; (d) experimental group and control group 1 students' scores on scientific attitude test (pre-test as well as post-test scores); and experimental group students' reactions towards the working of the individual components of the strategy and the strategy as a whole. Analysis of the data, results and the discussions thereof in respect of the three criteria of validation are presented under separate headings.

VALIDATION OF THE MULTIMEDIA INSTRUCTIONAL STRATEGY IN TERMS OF STUDENTS' ACHIEVEMENT

The effectiveness of the strategy has been studied in terms of:

(a) experimental group students' performance on unit tests and comprehensive tests;

(b) experimental group students' total achievement through the strategy, i.e., in terms of combined comprehensive test scores. To arrive at the combined comprehensive test scores, students' scores on both the comprehensive tests were added;

(c) experimental group students' performance on comprehensive test-I as compared to that of the performance of control group 1 students;

8

(d) experimental group students' performance on comprehensive test-I as compared to that of the performance of control groups 2 and 3 students; and

(e) experimental group students' performance on the annual examination conducted by the school authorities as compared to that of the performance of control group 1 students.

It may be mentioned that students' achievement on unit tests and comprehensive tests have been studied in terms of individial categories of objectives, viz., knowledge, understanding, application and skill separately, and also, all combined together.

ANALYSIS OF ACHIEVEMENT SCORES

The different criterion tests used in the study differed with regard to maximum marks in terms of each category of objectives as well as on the test as complete. To facilitate comparison of scores across these different tests, all the raw scores on the tests - objectivewise and combined - were converted into percentages. These percentages have been analysed using both descriptive and inferential statistical techniques. Since the statistical analysis is done on percentages, the obtained values are also in percentages.

Descriptive statistical techniques such as

9 percentiles, mean and standard deviation have been used to study the distributions of students' performance on the different criterion tests. For comparing experimental group students' performance with that of control group 1 students' performance on comprehensive test-I, and also on the annual examination conducted by the school authorities, Student's 't' test for correlated means has been used. This formula has been resorted to since both the groups were matched groups (refer 'Sample' presented earlier) and hence were treated as correlated groups. The formula used is given below:

$$SE_{D_{M_1} - M_2} = \sigma_D = \sqrt{(\sigma^2 Mx_1 + \sigma^2 Mx_2)\ (1 - r^2 xy)}$$

- Garrett (60)

For the purpose of comparing experimental group students' performance with that of the control groups 2 and 3 students' performance on comprehensive test-I, Student's 't' test for large group and independent samples has been used. The formula used is represented below:

$$\sigma D = \sqrt{\frac{\sigma^2_1}{N_1} + \frac{\sigma^2_2}{N_2}}$$ - Garrett (56b)

(Standard error of the difference between two uncorrelated means.

The results and discussion in respect of students' achievement through the strategy are presented in the following.

10 RESULTS AND DISCUSSION

Internal Validation:

Experimental Group Students' Performance on Unit Tests and Comprehensive Tests - Objectivewise as Well as Combined

TABLE 3.6

It is evident from Table 3.6 that excepting unit tests 2 and 8, students' mean performance on all other tests as regards objective knowledge is 75 per cent and above. On unit tests 2 and 8, students' mean performance is 73.77 and 65.00 per cent, with S.D.s of 16.45 and 21.20 per cent respectively. Examining the table at 50th percentile, it can be made out that 50 per cent of the students have obtained a score of 70 per cent and above on all tests. In fact, at this level, students' performance on units tests 3, 4, 5, 6 and 7 and on comprehensive test-I is quite noteworthy. Thirty per cent of the students have shown the positive trend in the attainment of mastery (100 per cent) by scoring 80 per cent and above on all tests, excepting unit test 8. The above interpretations indicate the extent to which the combinations of instructional inputs utilized for teaching different units had been effective in the attainment of terminal behaviours specified under objective knowledge.

TABLE 3.6

Percentiles, Means and S.D.s for the Experimental Group Students' Performance on Unit Tests and Comprehensive Tests on the Objective Knowledge

	Unit test 2	Unit test 3	Unit test 4	Unit test 5	Comprehensive Test-I	Unit test 6	Unit test 7	Unit test 8	Comprehensive Test-II
P_{90}	97.28	98.00	99.31	99.56	94.25	99.08	95.61	94.50	98.17
P_{80}	92.11	95.50	98 13	98.62	90.50	97.66	90.72	79.55	96.33
P_{70}	82.37	93.45	96.94	97.68	88.00	96.24	88.02	77.11	89.00
P_{60}	78.00	91.40	95.76	96.75	85.50	94.82	85.44	74.66	85.33
P_{50}	73.62	89.36	93.75	95.81	83.25	93.40	82.35	72.22	73.00
P_{40}	68.50	87.31	91.50	94.25	81.00	91.98	80.16	49.73	70.80
P_{30}	64.43	85.00	85.14	92.37	77.58	90.56	76.50	46.80	63.92
P_{20}	61.21	80.50	81.93	80.50	65.50	86.68	72.83	43.86	62.23
P_{10}	53.00	74.66	68.00	73.62	59.00	82.68	62.50	40.93	60.54
Mean	73.77	89.89	88.66	91.89	80.12	91.64	80.27	65.00	76.45
S.D.	16.46	8.40	12.58	9.70	12.93	5.22	13.73	21.20	16.46

11

TABLE 3.7

Observing the Table 3.7 for students' mean performance, it can be made out that excepting unit test 8, students' mean performance on all other tests is 70 per cent and above. Students' mean performance on comprehensive test-II is quite outstanding, being 80 per cent. From the table, it may be noticed that S.D.s for students' mean performance on unit tests 2 and 8, and on comprehensive test-I appear to be larger in comparison to S.D.s on other tests. These larger S.D.s indicate greater dispersion of scores on these tests. From the percentile positions for students' performance on different units, it can be observed that 70 per cent of the students have obtained a mark of 60 per cent and above on all tests, excepting unit tests 2 and 3. On these two unit tests, this level of performance (60 per cent) is reached by 60 per cent of the students. About 40 per cent of the students have obtained 75 per cent and above on all the tests. The performance of students on comprehensive test-II is worth considering, with 70 per cent of the students scoring above 95 per cent. As it has been noticed in Table 3.6, it can be noticed from the present table also that 30 per cent of the students have shown the positive trend in the attainment of mastery by scoring 80 per cent and above.

The above figures reveal the extent to which the combination of instructional inputs utilized for teaching

TABLE 3.7

Percentiles, Means and S.D.s for the Experimental Group Students' Performance on Unit Tests and Comprehensive Tests on the Objective Understanding

	Unit test 2	Unit test 3	Unit test 4	Unit test 5	Comprehensive Test-I	Unit test 6	Unit test 7	Unit test 8	Comprehensive Test-II
P_{90}	97.28	97.28	93.00	86.00	98.00	90.36	96.10	96.83	99.31
P_{80}	93.50	93.50	87.00	82.62	95.50	88.90	90.75	93.16	98.62
P_{70}	88.00	88.62	86.75	79.81	88.00	87.43	80.37	88.10	97.94
P_{60}	83.35	82.16	83.00	74.50	83.00	85.96	77.62	79.95	97.25
P_{50}	79.89	76.12	78.00	71.28	77.37	83.35	74.66	75.95	96.56
P_{40}	73.00	65.50	75.50	68.07	70.50	80.10	71.00	71.95	95.87
P_{30}	58.00	58.93	68.62	64.85	66.00	75.70	60.00	63.50	95.19
P_{20}	50.50	56.12	63.00	58.25	50.50	71.30	57.25	42.50	69.89
P_{10}	38.00	46.33	56.33	55.43	34.66	62.50	47.83	24.00	67.45
Mean	71.89	73.00	75.44	70.20	72.67	79.60	72.55	68.91	90.35
S.D.	22.75	19.23	16.00	13.55	21.87	11.55	17.44	26.01	12.15

12 different units had been effective in the attainment of terminal behaviours specified under objective understanding.

TABLE 3.8

Examining the Table 3.8 for students' mean performance on different tests, it can be made out that excepting unit test 2 and comprehensive test-I, on all other tests it has remained at 60 per cent and above. The S.D.s on most of the tests appear to be large, and indicate lesser homogeneity in students' performance on the tests. In fact, the wide dispersion of scores can be clearly made out from the percentile positions depicted in the table. Even with the wide dispersion of scores that can be noticed from the percentule positions, however, a few significant observations can be made. Excepting unit test 2 and comprehensive test-I, on all other tests 50 per cent of the students have obtained a score of 70 per cent and above; on unit test 4 and comprehensive test-II, it is 93 per cent and above. About 30 per cent of the students have shown the possibility of attaining mastery by scoring almost 80 per cent and above. It may be recalled that such a trend in the attainment of mastery has been observed in respect of objectives knowledge and understanding also.

The above interpretations indicate the extent to which the combinations of instructional inputs utilized for

13 teaching different units had been effective in the attainment of terminal behaviours specified under objective application.

TABLE 3.9

It may be observed from Table 3.9 that students' mean performance on all the 4 tests is less than 60 per cent. Examining the percentile positions, it may be noticed that 40 per cent of the students have scored 50 per cent and above on all the tests. A score of 60 per cent is reached by 20 per cent of the students on unit test 7, and also on comprehensive tests I and II. About 10 per cent of the students have shown the possibility of attaining mastery on both the comprehensive tests by scoring 80 per cent and above. These figures indicate the extent to which the combinations of instructional inputs utilized for teaching different units had been effective in the attainment of terminal behaviours specified under objective skill.

TABLE 3.10

It may be observed from Table 3.10 that students' mean performance on all the tests is 68 per cent and above. In fact, the mean performance on unit tests 3, 4, 5 and on comprehensive test-II is 79 per cent and above, with smaller

TABLE 3.8

Percentiles, Means and S.D.s for the Experimental Group Students' Performance on Unit Tests and Comprehensive Tests on the objective Application

	Unit test 2	Unit test 3	Unit test 4	Unit test 5	Comprehensive Test-I	Unit test 6	Unit test 7	Unit test 8	Comprehensive Test-II
P_{90}	95.50	99.17	98.83	97.35	97.18	93.71	89.42	96.83	98.98
P_{80}	91.00	97.85	97.50	94.70	92.50	88.00	83.14	93.16	97.95
P_{70}	67.85	96.52	96.00	92.05	82.50	83.11	78.16	89.92	96.93
P_{60}	61.42	94.25	94.50	88.57	70.00	77.33	74.50	87.83	95.91
P_{50}	49.54	83.62	93.00	82.14	49.06	70.00	70.83	85.73	94.88
P_{40}	45.45	74.07	91.50	65.00	46.25	49.20	63.20	83.64	93.86
P_{30}	41.36	70.85	79.00	47.50	40.83	40.40	43.00	81.54	92.84
P_{20}	34.00	60.50	74.50	40.00	22.50	33.00	33.60	75.00	91.81
P_{10}	12.50	42.50	48.83	18.33	3.75	14.66	23.50	55.30	90.79
Mean	55.22	78.00	84.61	69.11	55.50	60.50	60.68	82.09	93.86
S.D.	28.16	21.85	18.84	29.20	32.29	28.90	26.10	14.13	2.45

TABLE 3.9

Percentiles, Means and S.D.s for the Experimental Group Students' Performance on Unit Tests and Comprehensive Tests on the Objective Skill

	Unit test 2	Unit test 3	Unit test 4	Unit test 5	Comprehensive Test-I	Unit test 6	Unit test 7	Unit test 8	Comprehensive Test-II
P_{90}					85.00	62.07	76.57		92.67
P_{80}					68.18	54.13	70.28		78.23
P_{70}					64.09	52.13	57 20		75.76
P_{60}					60.00	50.13	54.26		73.17
P_{50}					49.16	42.35	51.33		70.59
P_{40}					41.66	34.33	38.28		47.38
P_{30}					19.16	32.50	35.14		44.00
P_{20}					11.66	30.66	32.00		40.61
P_{10}					5.62	20.50	16.80		21.00
Mean					45.67	41.10	47.96		58.00
S.D.					28.53	17.25	21.20		26.50

Unit tests 2, 3, 4, 5 and 8 did not contain items related to the objective skill.

TABLE 3.10

Percentiles, Means and S.D.s for the Experimental Group Students' Performance on Unit Tests and Comprehensive Tests on the Total Marks (Objectives Combined

	Unit test 2	Unit test 3	Unit test 4	Unit test 5	Comprehensive Test-I	Unit test 6	Unit test 7	Unit test 8	Unit test	Comprehensive Test.II
P_{90}	96.00	96.28	94.75	93.11	90.75	83.30	88.10	94.50		94.25
P_{80}	34.25	[illegible]5	92.[illegible]0	90.61	85.50	81.10	83.70	89.39		91.50
P_{70}	79.56	90.44	90.14	88.36	81.00	78.30	78.50	83.50		88.95
P_{60}	76.75	85.75	86.93	86.32	75.75	74.12	71.50	78.54		86.95
P_{50}	73 71	81.00	83.94	84.08	72.55	71.37	68.59	74.54		84 95
P_{40}	70.50	74.50	81.12	80.33	70.05	67.16	66.59	70.54		82.07
P_{30}	63.00	70.75	78.00	75.12	63.66	62.50	64.59	62.40		78.70
P_{20}	55.50	64.50	74.25	69.50	49.50	58.50	60.30	53.60		74.00
P_{10}	48.00	60.00	68.00	62.62	39.00	48.75	48.50	43.50		67.33
Mean	71.12	79.33	82.56	80.00	69.55	68.93	69.27	71.59		82.79
S.D.	16.97	13.55	10.89	12.88	18.00	12.40	14.39	18.08		10.33

14

S.D.s in comparison to S.D.s on other tests. A comparatively higher mean and smaller S.D. on these tests indicate greater homogeneity in students' performance on these tests. From the percentile positions depicted in the table, it can be made out that 90 per cent of the students have succeeded on all the tests by scoring 35 per cent, and which is generally regarded as passing marks. About 70 per cent of the students have obtained 60 per cent and above. In fact, this score of 60 per cent is reached by 90 per cent of the students on unit tests 3, 4, 5 and on comprehensive test-II. Another observation that is worth considering is the score obtained by the upper 30 per cent of students. They have secured 75 per cent and above on all the tests, which are generally considered as distinction marks. These figures speak about the effectiveness of the strategy in affecting the achievement of students.

As another index of internal validation, experimental group students' total achievement (scores on comprehensive tests I and II combined) through the developed strategy has been studied. Percentiles, means and S.D.s in respect of students' total achievement through the strategy are presented in Table 3.11.

15

TABLE 3.11

Percentiles, Means and S.D.s for the Experimental Group Students' Total Achievement Through the Strategy (Objectives as Well as for the Total Marks)

	Knowledge	Understanding	Application	Skill	Total marks
P_{90}	93.10	98.06	95.38	78.00	90.50
P_{80}	90.77	95.61	93.00	66.50	86.17
P_{70}	88.77	90.25	87.71	61.00	81.50
P_{60}	84.83	85.00	82.00	56.00	77.06
P_{50}	81.14	81.33	65.00	51.11	74.60
P_{40}	79.14	75.10	62.25	39.33	71.10
P_{30}	75.50	70.70	58.00	32.00	65.50
P_{20}	65.67	61.83	39.50	24.33	57.50
P_{10}	61.75	46.50	28.67	16.00	45.90
Mean	79.95	77.20	67.40	47.50	71.70
S.D.	11.95	18.25	24.30	11.60	15.50

It can be observed from Table 3.11 that students have tended to achieve more on the categories of objectives, viz., knowledge and understanding than on application and skill. The higher means and comparatively smaller S.D.s in respect of knowledge and understanding objectives are the evidences to this achievement. Further evidence can be obtained by observing the percentile positions in respect of these two objectives. Sixty per cent of the students

16 have secured 75 per cent and above on these two objectives. At least 50 per cent of the students have shown the positive trend of attaining mastery by obtaining nearly 80 per cent and above. Observing the Table 3.11 for students' performance on the objective application, it can be seen that 60 per cent of the students have secured 60 per cent and above. Application ability, being a higher cognitive ability, the very fact of 60 per cent of the students attaining 60 per cent of marks is encouraging to conclude that the strategy had been effective in developing application ability in students. As regards students' performance on the objective skill is concerned, the strategy does not seem to have affected much. Only 30 per cent of the students have secured a score of 60 per cent and above. Just 10 per cent of the students have scored above 78 per cent, whereas, on all the other three objectives 40 per cent of the students have scored 78 per cent and above. In fact, such a trend of low performance on this objective has been noticed on the unit tests 6 and 7, and on the individual comprehensive tests.

It may be remembered that the central theme of the present investigation has been to systematize science instruction at VIII std. level. This has been attempted through the development of a multimedia instructional strategy which could be used in the existing classroom situations, without causing undue disturbance in the functioning of the present classrooms. Evidently, the

17 validation of the strategy should be in terms of students' development and achievement of specified instructional objectives. The study of the experimental group students' performance on unit tests and comprehensive tests is in effect to this. The interpretations of Tables 3.10 and 3.11 reveal that through a well planned and organized instructional strategy it is possible to attain more instructional outcomes. The very fact that 90 per cent of the students scoring 35 per cent marks and above (pass level marks) and 70 per cent of the students scoring 60 per cent and above (60 per cent is generally considered as first class marks) on all the tests (refer Table 3.10) is a direct evidence to this. The interpretations are in line with the findings of the earlier studies (Yadav and Govinda, 1976; Sansanwal, 1978; Seshadri, 1979 and Shah, 1978) conducted in this area of educational research, viz., systematisation of instructional process. These studies have shown that enrichment brought into the instructional system by including components such as library work, practical work, discussion, tutorials, games, etc., and using them along with programmed learning material had positively influenced the achievement of students. It may be mentioned that the studies quoted earlier had programmed learning material as a fixed component in the instructional strategy to impart basic information, and the other components supplemented PLM. The present study differs from the above by not having PLM as a main component of instruction. Various instructional components have constituted

18 the strategy. These components have been selected according to their potentialities in achieving the specified terminal behaviours for each unit, the structure of the content to be taught, learner's characteristics, accessibility and feasibility of the components selected, etc. In other words, it is a carefully planned instructional system development approach, wherein different methods and media have been utilized keeping in mind various considerations to achieve the delineated instructional objectives. One pertinent remark at this juncture is, even with such consciously planned and sequenced learning material, as it could be made out from Tables 3.6 to 3.11, a mastery of 100 per cent has not been achieved. This lack of attainment of mastery may be attributed to the fact that individual differences exist among learners in respect of the mastery of prerequisite concepts, acquisition of prerequisite abilities to solve problems which involve operation of higher mental processes, in their learning style, study habits, etc. One way, probably, to minimize these individual differences might be through incorporating into the instructional process diagnostic and remedial measures. The instructional system may have to have built-in mechanism for identifying and analysing difficulties of learners in learning concepts - analysis of difficulties should include both where the learner is facing difficulty and why he is facing difficulty. In an instructional programme, diagnosis could be accomplished by periodically providing students with diagnostic tests

19 related to the instructional objectives. Remediation follows diagnosis. It is an activity wherein learners select or are directed to further instruction based on the results of diagnostic tests. The mastery learning strategy of Bloom (1971) and personalized instruction system of Keller (1974) have thrown sufficient light on minimizing individual differences in learners, and on improving learning effectiveness. Both the strategies place heavy emphasis on diagnostic testing with feedback followed by additional instruction through alternative modes of instruction. Evidence in respect of this can be seen in the works of Kim Hogwan et al. (1969); Kersh (1970); Gunter (1974); Besler (1975); Razia (1975); Wyckoff (1975); Crotty (1976); Duncan (1976); Block and Burns (1976); and Swanson (1976). It may be mentioned that the present study did not include the characteristics of mastery learning strategy mainly due to the fact that the strategy had to function under certain restrictions such as availability of time and other resources, and fixed syllabus. Therefore, sufficient attention could not be paid to accommodate in the strategy, to a greater degree, individual differences of the learners, However, the strategy has served its purpose in being an attempt towards systematisation of the instructional process.

External Validation:

Besides internal validation, a few external criteria too have been employed against which the strategy

has been validated in terms of students' achievement. The results and discussions in respect of this are presented in what follows.

1. As an index of external validation, experimental group students' performance on comprehensive test-I has been compared with that of the control group 1 students' performance. Description about control group 1, and administration of comprehensive test-I to this group have already been presented respectively under 'Sample' and 'Implementation of the multimedia instructional strategy' in this Section. Comparison has been made on the basis that (a) both the groups belonged to the same academic year (1978-79), and were matched on their achievement in std. VII science examination; (b) students of both the groups had completed their std.VII from the same institution, viz., Shreyas Vidyalaya, Baroda; (c) the broad objectives set for the course were same for both the groups; (d) the content units and their sequence remained same for both the groups, and lastly, the test (comprehensive test-I) remained same for both the groups.

The percentiles, means, S.D.s and 't' values computed for the experimental group and the control group 1 students' performance on comprehensive test-I as regards the four categories of instructional objectives, namely, knowledge, understanding, application and skill separately, and all combined (total marks) have been presented in Tables 3.12 to 3.16 respectively.

TABLE 3.12

Percentiles, Means, S.D.s and 't' Value for the Experimental Group and the Control Group 1 Students' Performance on the Comprehensive Test-I
Knowledge Objective

Groups	No. of students	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't' value	Level of significance
Experimental group	45	59.00	65.50	77.58	81.00	83.25	85.50	88.00	90.30	94.25	30.12	12.93	15.88	**
Control group 1	45	20.30	26.00	30.00	33.12	36.33	40.33	45.10	53.50	57.78	41.20	13.18		

** Significant at 0.01 level

TABLE 3.13

Percentiles, Means, S.D.s and 't' Value for the Experimental Group and the Control Group 1 Students' Performance on the Comprehensive Test-I
Understanding Objective

Groups	No. of students	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't' value	Level of significance
Experimental group	45	34.66	50.50	66.00	70.50	77.37	83.00	88.00	95.50	98.00	72.67	21.87	14.73	**
Control group 1	45	10.00	13.00	15.70	18.10	24.50	26.34	28.19	31.25	37.25	23.46	11.90		

** Significant at 0.01 level

TABLE 3.14

Percentiles, Means, S.D.s and 't' Value for the Experimental Group and the Control Group 1 Students' Performance on the Comprehensive Test-I
Application Objective

Groups	No. of students	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't' value	Level of significance
Experimental group	45	3.75	22.50	40.83	46.25	49.06	70.00	82.50	92.50	97.18	55.50	32.29	7.92	**
Control group 1	45	1.00	2.00	3.00	4.00	4.50	17.16	27.50	31.94	49.50	16.48	17.65		

** Significant at 0.01 level

TABLE 3.15

Percentiles, Means, S.D.s and 't' Value for the Experimental Group and the Control Group 1 Students' Performance on the Comprehensive Test-I
Skill Objective

Groups	No. of students	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't' value	Level of significance
Experimental group	45	5.62	11.66	19.16	41.66	49.16	60.00	64.09	68.18	85.00	45.67	28.53	6.95	**
Control group 1	45	1.60	3.20	1.80	8.50	15.45	17.64	19.82	27.83	40.20	16.14	13.30		

** Significant at 0.01 level

TABLE 3.16

Percentiles, Means, S.D.s and 't' Value for the Experimental Group and the Control Group 1 Students' Performance on the Comprehensive Test.I
Total Marks (Objectives Combined)

Groups	No. of students	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't' value	Level of significance
Experimental group	45	39.00	49.50	63.66	70.05	72.55	75.75	81.00	85.50	90.75	69.55	18.00	14.88	**
Control group 1	45	13.30	16.75	19.72	22.38	25.21	28.64	31.75	35.00	47.50	27.00	11.59		

** Significant at 0.01 level

21 It may be seen from Tables 3.12 to 3.16 that all the 5 obtained 't' values are significant at .01 level. Looking into the mean performance of both the groups of students, it becomes evident that the experimental group students' mean performance is higher than that of control group 1 students' performance on all the 4 instructional objectives as well as on the test as a whole. This indicates the superior performance of the experimental group as against the control group 1 on all the 4 instructional objectives and on the test as a whole. The higher performance of the experimental group students is also apparent from the different percentile positions depicted in the tables.

2. As another index of external validation, the experimental group students' performance on comprehensive test-I has been compared with that of the control groups 2 and 3 students' performance. Description about the control groups 2 and 3, and administration of comprehensive test-I to these groups have already been given respectively under 'Sample' and 'Implementation of the multimedia instructional strategy' in this Section. A comparison of this type is an Expost Facto comparison as explained by Kerlinger (1973) and Tuckman (1979). With regard to comparability of the groups, it may be considered that all the three groups as random samples belonging to the same std.VIII student population. However, taking into cognizance of the possibility of congregation of students belonging to a

22 particular ability level in any one of the control groups, it was thought methodologically more meaningful to consider the performance of both the control groups together and compare it with experimental group. The comprehensive test-I and the content covered in it remained same for both the experimental group and control groups 2 and 3 (combined). Specifically, about the content covered in the test, it may be mentioned that in the control groups 2 and 3 also the same units, viz., units 2, 3, 4 and 5 were covered that year (1977-78). For the purpose of comparison, from the total of 92 students belonging to the control groups 2 and 3 (combined), a total of 86 has been considered since 6 students; 3 students from each group were absent for the test.

The percentiles, means, S.D.s and 't' values in respect of the experimental group and the control groups 2 and 3 (combined) students' performance on the comprehensive test-I as regards the four categories of instructional objectives, viz., knowledge, understanding, application and skill separately, and all combined together (total marks) have been presented in Tables 3.17 to 3.21 respectively.

TABLE 3.17

Percentiles, Means, S.D.s and 't' Value for the Experimental group and the Control Groups 2 and 3 Students' (Combined) Performance on the Comprehensive Test-I - Objective Knowledge

Groups	No. of students	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't' value	Level of significance
Experimental group	45	59.50	65.50	77.58	81.00	83.25	85.50	88.00	90.50	94.25	80.12	12.93	15.17	**
Control groups 2 and 3 (combined)	86	35.36	39.31	42.50	44.46	46.00	47.56	51.17	5o.40	61.25	47.20	9.30		

** Significant at o.01 level

TABLE 3.18

Percentiles, Means, S.D.s and 't' Value for the Experimental Group and the Control Groups 2 and 3 Students' (Combined) Performance on the Comprehensive Test-I - Objective Understanding

Groups	No. of students	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't' value	Level of significance
Experimental group	45	34.66	50.50	68.00	70.50	77.37	88.00	88.00	95.50	98.00	72.67	21.87	13.93	**
Control groups 2 and 3(Combined)	8o	11.03	13.90	16.39	18.78	21.17	27.04	30.35	33.65	38.05	24.20	11.25		

** Significant at o.01 level

TABLE 3.19

Percentiles, Means, S.D.s and 't' Value for the Experimental Group and the Control Groups 2 and 3 Students' (Combined) Performance on the Comprehensive Test-I - Objective Application

Groups	No. of students	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't' value	Level of significance
Experimental group	45	3.75	22.50	40.33	46.25	49.06	70.00	82.50	92.50	97.18	55.50	32.9	3.31	**
Control groups 2 and 3 (Combined)	86	16.46	18.25	20.04	31.32	32.42	33.53	34.63	45.60	50.20	32.40	15.45		

** Significant at o.01 level

TABLE 3.20

Percentiles, Means, S.D.s and 't' Value for the Experimental Group and the Control Groups 2 and 3 Students' (Combined) Performance on the Comprehensive Test-I - Objective Skill

Groups	No. of students	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't' value	Level of Significance
Experimental group	45	5.62	11.66	19.16	41.66	49.16	60.00	64.09	68.18	85.00	45.67	28.53	1.61	**
Control groups 2 and 3 (Combined)	86	2.81	5.90	8.77	16.96	24.86	27.93	34.93	38.00	47.33	24.15	17.90		

** Significant at 0.01 level

TABLE 3.21

Percentiles, Means, S.D.s and 't' Value for the Experimental Group and the Control Groups 2 and 3 Students' (Combined) Performance on the Comprehensive Test-I - Total Marks (Objectives Combined)

Groups	No. of students	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't' value	Level of significance
Experimental group	45	39.00	49.50	63.66	70.05	72.55	75.75	81.00	85.50	90.75	69.55	18.00	12.56	**
Control groups 2 and 3 (Combined)	86	24.35	27.92	30.42	32.07	33.73	35.71	37.97	40.67	44.25	34.25	7.6		

** Significant at 0.01 level

23 It is evident from Tables 3.17 to 3.21 that the 't' values obtained for significance of difference between means of the experimental group and the control groups 2 and 3 (combined) on the four instructional objectives separately, and all combined (total score) is significant at α.01 level. From the mean performances of both the groups, it can be observed that the performance of the experimental group students is higher than that of the control groups 2 and 3 (combined). This indicates the superior performance of the experimental group students on the four instructional objectives, namely, knowledge, understanding, application and skill, and on the test as a whole as compared to that of the control groups 2 and 3 (combined) students. The higher performance of the experimental group students can also be made out from the different percentile positions depicted in the tables.

3. Experimental group students' performance vis-a-vis that of control group 1 students' performance on the annual examination conducted by the school authorities has been considered as another index of external validation. Details in respect of the annual examination have already been given under 'Instrumentation' in Section I of this chapter. It may be mentioned that the test remained same for both the groups, since the content taught till that point of time (towards the close of the academic year, 1978-79) remained same.

24 The percentiles, means, S.D.s and 't' value in respect of the experimental group and the control group 1 students' performance on the annual examination are given in Table 3.22 on the next page.

Looking into the percentile points depicted in Table 3.22 in respect of experimental group students' performance, it may be noticed that 70 per cent of the students have scored above 35 per cent, that is, passing marks. At least 30 per cent of the students have obtained ≥ 60 per cent and above, which are generally considered as first class marks. Further, 10 per cent of the students have scored more than 75 per cent which ≥ are distinction marks. As against 70 per cent of the experimental group students, only 40 per cent students of the control group 1 have completed the exam. successfully by scoring 35 per cent marks. About 20 per cent of the control group 1 students (as against 30 per cent of the experimental group students) have attained first class marks of 60 per cent. In fact, none have scored distinction marks, that is, 75 per cent. From the table, it may also be noticed that the 't' value obtained for the significance of difference between the two means is 3.52 and is significant at 0.01 level. This indicates that there is significant difference between the two means. Looking into the mean performance of the two groups, it may be seen that the mean performance of the experimental group is higher in comparison to that of the control group 1. The higher mean in respect of the experimental group indicates the superior

TABLE 3.22

Percentiles, Means, S.D.s and 't' Value for the Experimental Group and the Control Group 1 Students' Performance on the Annual Examination

Groups	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	Mean	S.D.	't'	Level of significance
Experimental group	19.50	32.00	38.00	42.50	48.66	55.75	61.37	69.50	85.50	50.16	22.25		
												3.52	**
Control group 1	10.75	20.61	23.38	29.50	34.50	44.50	57.00	62.50	70.75	39.50	22.16		

** Indicates significance at o.01 level.

25 performance of the experimental group students as compared to that of the control group 1 students on the annual examination.

In all the three comparisons made earlier, namely, experimental group students' performance vis-a-vis (a) control group 1 students' performance on comprehensive test-I (refer Tables 3.12 to 3.16); (b) control groups 2 and 3 (combined) students' performance on comprehensive test-I (refer Tables 3.17 to 3.21); and (c) control group 1 students' performance on the annual examination conducted by the school authorities (refer Table 3.22), the superior performance of experimental group students was observed. The experimental group being exposed to multimedia instructional strategy, what could be discerned from their superior performance as regards effectiveness of the developed instructional strategy is that the strategy had been effective in terms of bringing about greater learning effects.

The results in respect of the different validatory indices reveal the extent to which the strategy had been effective in the attainment of instructional objectives. The results speak of the possibility of attainment of greater number of instructional objectives through systematising the instructional process.

26 VALIDATION OF THE MULTIMEDIA INSTRUCTIONAL STRATEGY IN TERMS OF THE DEVELOPMENT OF SCIENTIFIC ATTITUDE IN STUDENTS

Development of scientific attitude in students constituted one of the objectives of science teaching at VIII std. level. Being an objective attempted to be attained through the strategy, wherein different inputs (components) are selected and organized in a systematic manner to provide appropriate learning experiences, the potentiality of the strategy to the promotion of scientific attitude is ensured. While providing learning experiences through the strategy, as it may be recalled from Section I of this chapter, deliberate efforts wherever appropriate to develop behaviours related to scientific attitude were made. A few illustrations to this effect are cited below:

1. In a few instructional units, the historical background of scientists and their contributions in terms of knowledge development in the field of science were traced.

2. Closely related to the above, instances indicating how knowledge gets refined in the light of evidences to the contrary of what exists were pointed out with a view to indicating that accumulation of knowledge is not a finished enterprise.

3. While providing learning experiences, or even

27

while introducing instructional units, the curiosity of the students was aroused to know what followed.

4. Students were encouraged to participate in group discussions, Further, they were also encouraged to carry out activities on an individual basis as well as in groups.

5. At many places in the units, simple experiments structured in accordance with the principles of guided discovery were deliberately included to developed heuristic behaviour.

It should be noted that these different learning experiences with regard to their contribution towards the development of scientific attitude are to be seen in a cumulative manner, and not in isolation. This is due to the view held in the investigation that the construct 'Scientific Attitude' is a composite of different behaviours, and possessing any one of these would not position an individual high on scientific attitude. Precisely, in the investigation, 'Scientific Attitude' has been considered as a totality of different behaviours. It is due to this consideration made in the investigation, one may not find learning experiences for developing each of the component behaviours of scientific attitude in each and every instructional units constituting the instructional strategy. On the other hand, wherever the development of particular behaviours could be

28 attempted, the learning experiences have been provided accordingly. Further, it may also be mentioned that the learning experiences catering to the development of behaviours related to scientific attitude run consistently through the instructional units in various ways. They are neither concentrated heavily at any one particular juncture, nor intermittent in their occurrence.

Obviously, when concerted and deliberate attempts have been made to incorporate learning experiences which would lead to the development of behaviours related to scientific attitude, studying the extent to which it has been developed in students would reflect the effectiveness of the learning experiences provided for its development. It is in this connection, the extent of the development of scientific attitude (gain from pre-test to post-test) has been considered as a criterion for validating the developed strategy.

Details pertaining to the development of scientific attitude test have already been presented under 'Instrumentation' in Section I of this chapter. Particulars regarding the sample utilized for studying this aspect, and, administration of the test have already been provided under respective headings 'Sample' and 'Implementation' of the multimedia instructional strategy' in this Section. It may be mentioned that for the purpose of validation, the responses of 5 students of the control group 1 were to be

29 discarded, since these students had not responded to all the items on the test.

ANALYSIS OF SCORES ON SCIENTIFIC ATTITUDE TEST

In all, 4 sets of scores were available; pre-test and post-test scores of the experimental group, and similarly, pre-test and post-test scores of the control group 1. Mean and S.D. for each set of scores were calculated. Student's 't' test was used for (1) finding out significant difference between means of pre-test and post-test scores of the experimental and the control group 1 separately, and (2) for comparing means of pre-test and post-test scores of the experimental group with that of the control group 1.

For finding out the significant difference between means of pre-test and post-test scores of the experimental group and the control group 1, the 't' formula used was:

$$SE_D = \sqrt{\sigma^2 M_1 + \sigma^2 M_2 - 2r_{12} \sigma M_1 \sigma M_2}$$

- Garrett (59)

For the purpose of comparing means of pre-test and post-test scores of the experimental group with that of the control group 1, 't' formula for independent and uncorrelated means was used. This formula was used since the groups were considered as independent, and therefore not correlated with respect to the criterion under measurement. The formula used has been given below.

30 $$\sigma D = \sqrt{\frac{\sigma 2_1}{N_1} + \frac{\sigma 2_2}{N_2}}$$ - Garrett (56b)

In the following are presented the results and the discussion thereon in respect of students' performance on scientific attitude test.

RESULTS AND DISCUSSION

TABLE 3.23

't' Values for Significance of Difference Between Means of Pre-test and Post-test Scores - Experimental Group and Control Group 1, Separately

Groups	No. of students	Nature of the scores	Mean	S.D.	Obtained 't' value	Level of significance
Experimental group	45	Pre-test Scores	32.26	4.94	8.47	**
		Post-test Scores	38.02	5.61		
Control group 1	40	Pre-test Scores	30.20	4.59	5.08	**
		Post-test Scores	35.32	6.40		

** Indicates significance at .01 level

As can be seen from the Table 3.23, both the groups,

31 namely, experimental and control group 1 show a significant difference in their means from pre-test and post-test, the difference being in favour of post-test. This indicates that there is development of scientific attitude in both the groups over the period of time (one complete academic year), since both the groups had been exposed to science teaching; of course, the experimental group being exposed to multi-media strategy and the control group 1 to the regular class-room teacher. However, the higher mean and lower S.D. obtained by the experimental group on the post-test vis-a-vis that of the control group with a relatively lower mean and higher S.D. suggest that, perhaps, learning experiences planned deliberately to develop this attribute might have contributed to a greater extent for its development. To study this further, the means of pre-test and post-test scores of the experimental group have been compared with the corresponding means of the control group 1.

TABLE 3.24

It may be observed from Table 3.24 that there is no significant difference between means of the groups on pre-test. On the contrary, on the post-test, the 't' value being 2.06 is significant at .05 level. This indicates that there is significant difference between the means of the two groups on post-test. The difference being in favour of

32

TABLE 3.24

't' Values in Respect of the Comparison of the Means of the Pre-test and Post-test Scores of Experimental Group with that of Control Group 1

Nature of scores	Groups	No. of students	Mean	S.D.	Obtained 't' value	Level of significance
Pre-test Scores	Experimental group	45	32.26	4.94	2.0	N.S.
	Control group 1	40	30.20	4.59		
Post-test Scores	Experimental group	45	38.02	5.61	2.06	*
	Control group 1	40	35.32	6.4		

N.S. - Not significant
* Indicates significance of 0.05 level

It may be observed from Table the experimental group indicates that the experimental group had developed scientific attitude to a significant extent in comparison to that of the control group 1 over a period of one academic year.

Recalling that deliberate attempts were made in the strategy to develop scientific attitude in students through incorporation of various activities, the results of the comparisons made earlier (refer Tables 3.23 and 3.24) suggest the possibility of planned instruction in contributing to the development of scientific attitude, and thereby reflects

33 the effectiveness of the developed multimedia instructional strategy.

VALIDATION OF THE MULTIMEDIA INSTRUCTIONAL STRATEGY IN TERMS OF STUDENTS' REACTIONS

It may be remembered that for validating the strategy in terms of students' reactions, reactions were collected from 45 students of the experimental group. These reactions were collected through interviews and a reaction questionnaire. Details pertaining to them can be found in Section I of this chapter under the heading 'Instrumentation'. Details regarding how students' reactions were obtained through interviews and questionnaire have already been presented in this Section under the heading 'Implementation of the multimedia instructional strategy'. In what follows are presented details pertaining to analysis of these reactions to study the effectiveness of the individual components of the strategy, and the strategy as a whole.

ANALYSIS OF STUDENTS' REACTIONS

Students' reactions towards working of the individual components of the strategy, and the strategy as a whole were analysed for their content, and categorised on the basis of the themes expressed. For each item, the number of students expressing a particular theme were pooled. The pooled numbers (frequency) thus arrived at were further converted into percentages. To facilitate easy reading, these percentages have been expressed in whole numbers.

Students' reactions towardseach component of the strategy, and the strategy as a whole are presented hereunder, componentwise.

RESULTS AND DISCUSSION

Introduction by the Teacher

As regards the inclusion of this component in the strategy, 98 per cent of the students have reacted that it is a necessary component. Only one student has expressed that there was no need of introduction. However, no specific reason is given by the student for his unfavourable reaction. The reasons given by those students who have shown positive reactions towards this component are (1) an introduction to the unit in the beginning helped them in getting a clearer view about the concepts they would be learning in that particular unit, and also as to how they would be learning that unit; (2) It helped them in recalling what they had already studied about the concepts in their previous classes, and linking them with other concepts of the unit which they would be studying; and (3) it helped them for quick revision. These reactions of the students validate the assumption on which this has been chosen as a component of the strategy.

35 Programmed Learning Material and Deviated PLM

Programmed Learning Material:

About 70 per cent of the students have reacted favourably to this component. They have expressed that it was a novel way of learning and was interesting too. The main reasons for their positive reactions have been the following:

(a) The small steps or frames enabled them to understand the ideas presented in the frame easily; (b) the facility for in-built feedback - checking their own answers; and (c) they could learn the concepts on their own. The rest of the students (30 per cent) have shown negative reactions towards this component. Their reactions have been centred round (a) length of the frame and number of frames assigned to read at home, and (b) prompts provided in the material, As regards length of the frames, the reactions were that many frames were too large and sometimes it was boring to go through. They have suggested that the information in a frame should not exceed more than 3 to 4 lines, so that they can concentrate more. Regarding the number of frames assigned to read at home, the reaction has been that it was difficult and boring to go through 40 to 50 frames, specially when they were assigned home work by other teachers. As regards prompts, these students (70 per cent) have reacted that prompts should not be provided in the

material. The reasons given for this have been varied. They are (a) prompts tempted them to copy the answers, and similarly the correct answers given after each frame; and (b) it hindered their thinking since they were often tempted to look for only prompts in the frame.

As regards the acceptability of programmed learning material as a regular instructional techniques, from among the 70 per cent of students who have shown positive reactions towards the component, 35 per cent have remarked that it should be utilized for teaching all the difficult concepts in the course. The rest have expressed that it should be utilized only in a few units.

Deviated PLM:

A good majority of students (96 per cent) have reacted favourably towards this component. They have expressed, in general, that it was very interesting and pleasing to learn through the technique. The reasons they have expressed are as follows:

(a) Simple and lucid diagrams embedded in the learning material helped them to understand the concepts without much difficulty; (b) small paragraphic presentation of the information; and (c) intermittent questions and summaries helped them in recalling and revising, and lastly, the facility for in-built feedback mechanism through correct answers.

38 positive reactions towards this component, 20 per cent of students have expressed that as this technique gives more prominence to teacher's explanation, they experienced a passive role. It may be mentioned that this percentage of students used to participate in discussion sessions and other classroom activities to a greater extent. They have suggested that during lecture sessions, students' participation should also be given due prominence.

Team Teaching

With regard to this technique 53 per cent of the students have expressed that teaching by two teachers in the class helped them to think in divergent ways and arrive at their own conclusion. However, they have expressed that in this technique even participation from students should also be ensured. The rest of the students (47 per cent) have reacted negatively to this technique by expressing that presentation of concepts in an argumentative manner by two teachers confused them, and it appeared as if some 'drama' was going on in the class. This category of students have preferred single teacher presentation to team approach.

Pupil Activities and Demonstrations by the Teacher

It may be recalled from Section I of this chapter that individual student activities were included in the instructional material at various places with specific

39 instructions for carrying them out. In respect of this, about 92 per cent of the students have remarked that they could carry out all the activities at home, and such activities helped them in understanding the concepts better. Out of this 92 per cent, about 20 per cent of the students have expressed that some of the activities were too simple for their level, and hence it would have been much more interesting if challenging activities had been incorporated. Only 8 per cent of the students have expressed that they could not perform all the activities due to lack of availability of materials at home.

As regards demonstrations of experiments by the teacher, almost all the students (95 per cent and above) have remarked that demonstrations helped them in (a) getting a practical knowledge about certain phenomena; (b) understanding concepts better when read later at home; (c) getting an idea as to how to arrange apparatus and carryout the experiments, and lastly, helped in describing the experiments in their own words. However, a suggestion given is that students should be involved in arranging the apparatus, carrying out the experiments and in drawing the diagram of the apparatus.

Inquiry Technique

Almost 65 per cent of the students have expressed positive reactions towards this component. These students

have preferred learning through inquiry technique to teacher demonstrations. The main reasons offered by these students in favour of this technique are (1) the technique enabled them to guess different factors of an event or phenomenon; (2) through this technique, they got an opportunity to hypothesise the effects of different factors, and test them through setting up experiments, and (3) it helped them to write the plan, procedure and findings of the experiments which they did, in their own words.

However, about 20 per cent of the students expressed that they learnt better when teacher demonstrated and explained things, than through inquiry technique. The reasons being that when teacher demonstrated and explained, there was less confusion and disturbance in the class, which helped them to concentrate on experiments and understand them. But for the above reasons, even this percentage of students have expressed that learning through inquiry technique is more interesting and challenging than learning through demonstrations and explanation by the teacher. Fifteen per cent of the students have not expressed their reactions by not answering the questions related to this component.

Audio Visual Presentations

As regards this component, mainly four aspects were focussed. They were (a) how did audio visual presentations appeal to you, (b) how did work-booklets help you,

41 (c) how did the handouts supplied after the presentation help you, and lastly, would you prefer teacher to explain using blackboard to transperencies and slides?

Most of the students (90 per cent) have offered favourable reactions in respect of all the above four aspects. They have mentioned that they could understand easily because teacher used to explain the concepts with the help of transparencies. It is evident from their reactions that the aspect of focussing students' attention to particular points when the transparencies were projected had appealed to them. Further, these students have also expressed that they were more attentive during audio visual presentations than in other classes.

Regarding the work booklets supplied, all the 90 per cent of the students have remarked that it was helpful in recalling the ideas they had learnt during audio visual presentations, and also as a sort of self-check for their understanding about the concepts. It is also expressed by the students that by answering the questions in the work booklets, they could remember the ideas better. Similarly, they have offered positive reactions in respect of the handouts supplied to them after the entire presentation was over. The reason expressed is that handouts helped them in revising at the time of criterion tests and examination. As regards the question, whether they preferred learning through this technique to that of teacher's explanation

42 with aids', the reaction in general has been 'Yes'. However, they have offered a few suggestions for the improvement of audio visual presentations. They are (1) coloured transparencies should be made use of instead of only black and white; (2) teacher's explanation should be taped; and lastly, both transparencies and recorded tape should be made available for reviewing during leisure time.

The above reactions reflect the effectiveness of the technique as an important instructional component.

Historical Background of Scientists

It may be mentioned that historical backgrounds of scientists and scientific discoveries were presented in the learning material wherever appropriate, with a view to imbibing in students as to how scientists discovered certain significant principles and laws in science, what was the approach adopted by them, the qualities they exhibited in their pursuit of discovery, etc. Almost all the students (95 per cent) have expressed that they enjoyed this section very much. They have also expressed that more of such information should be incorporated in the learning material, as it would help them in knowing more about various scientists and their discoveries. About 16 per cent of the students have mentioned that such information prompted them to read additional information related to the discoveries, and also to know about other scientists too.

43 Discussion Sessions

With regard to inclusion of this component in the strategy, 70 per cent of the students have expressed that it was quite useful to them. Of this percentage of students, many (57 per cent) have expressed that discussions helped them in getting their doubts cleared. A few (8 per cent) have remarked that besides being helpful for getting their doubts cleared, discussions also helped them in developing confidence to put forth their view points. Two students (5 per cent) have expressed that participating in discussions helped them in shedding their shyness in expressing their view points. The rest 30 per cent of the students have remarked that discussion sessions were just repetition of what teacher had explained in the class, and in this respect was just waste of time.

As regards discussion sessions organized at the completion of each unit, all the 70 per cent of students (referred earlier) have opined that (1) it served them in revising what they had learnt in that particular unit in a short time, (2) it facilitated remembering the ideas, and lastly, it helped them in getting a comprehensive view of what all they had learnt in that unit. With regard to the question, how did other's participation in the discussion sessions help you?, they have expressed the following reactions:

44 (a) participation by other students helped in clarifying doubts,

(b) helped in getting confidence to participate,

(c) helped in exchanging views, and

(d) helped in judging our own reasoning as against others.

The above remarks of the students as regars the different aspects of the component 'discussion' indicate that it has served as an effective instructional technique.

Summaries

All the students have expressed that summaries provided at the end of a few concepts in the units as well as at the end of each unit helped them in (a) revising quickly the concepts learnt till then and also at the time of examination; (2) reviewing the entire unit in a brief period of time; and (3) in getting a link for the next unit. However, they have expressed that summaries should be still briefer, and important points should be underlined to facilitate revising and remembering at the time of examination.

Criterion Tests and Feedback

The favourable reactions expressed by almost all

45 the students (95 per cent) in respect of criterion tests have been centred around the following points:
(a) helped in knowing our own level of understanding about the concepts in the unit, and (b) helped in preparing for the final examination. As regards feedback sessions organized after criterion tests, they have expressed that these sessions helped them in understanding and rectifying their errors committed in the criterion tests, and also in clarifying certain misconceptions held by them. Further, they have also remarked that these sessions helped them for further improvement. However, one suggestion offered by the students is that they should be allowed to retain criterion test papers after feedback sessions, so that it would help them to revise at the time of annual examination.

Exercises and Assignments

As regards exercises and assignments, about 50 per cent of the students have expressed that these helped them to prepare for the criterion tests, and also in practising diagrams. Nearly 40 per cent of the students have expressed that they did not find sufficient time to complete exercises and assignments, since they were to prepare for other subjects also. Ten per cent of the students have expressed that it was just a repetition and was boring to them. The percentage of students who had completed all the exercises and assignments have suggested that these exercises and assignments

46 must be graded and the marks should be considered for declaring ranks at the end of the year. These students have also mentioned that the feedback given on the exercises and assignments motivated them to do other assignments and exercises.

Besides seeking reactions of students towards working of the individual components of the strategy, students' reactions towards 'Learning science through multimedia strategy' and also their suggestion for its improvement have been sought. They have been focussed hereunder.

All the students have expressed that it was a novel approach of learning and liked it very much. In general, they have remarked that all other subjects - at least science - in their next standard should be taught through this approach. For the question 'did you find any improvement in your science achievement?, 80 per cent of the students have expressed that they could notice definite improvement in their achievement in science as compared to that of their previous achievement in science subjects. However, they have expressed that learning science through this approach is time consuming and requires additional efforts on their part. As regards suggestions for improvement of the strategy, they have suggested that learning material should be printed and supplied to them in the form of text-books so that they can easily handle them.

It may be noticed from the reactions of the students

towards various components that excepting the component team teaching, for all other components the reactions have been quite favourable - 70 per cent and above have shown positive reactions. As a matter of fact, for components such as deviated PLM, lecture method, summaries, criterion tests and feedback etc., 90 per cent and above have expressed favourable reactions. It may be recalled from Chapter I that multimedia strategy is conceived as constituting of different methods and media (components). Each unit in the course has been taught through a combination of components. The favourable reactions of students towards almost all the components of the strategy and also their reactions towards 'learning science through multimedia strategy' indicate that the strategy has worked to a satisfactory level.

However, it should be mentioned that students' reactions towards various components of the strategy - both favourable and unfavourable - are nothing but their perceptions about the working of the different components. One cannot rule out the possibility of existence of individual differences in perception. Eventhough different components of teaching were utilized in the strategy, it should be mentioned that they were not tailored for each individual students' preferences for the methods. Further, the components of the strategy were selected keeping in mind certain gross learner characteristics.To that extent,

48

the developed strategy did not have flexibility for each individual to select the component through which he likes to learn most. Such strategies tailored for each individual student needs and learning style will have several alternative modes of treatment of the same unit. As mentioned earlier, the strategy attempted through the present investigation lacked this flexibility. Because of this lack of flexibility one can expect unfavourable reactions at least towards a few components.

It may also be mentioned that learning through a strategy of the present kind, demands a new set of behaviours on the part of the learners such as interest, attitude, study habits, etc. In other words, a different look towards the very process of learning itself. These behaviours, as a matter of fact, get developed over a period of time. And, unless these behaviours are developed, the learners, at least a few of them, are likely to show unfavourable reactions.

What is discussed in the earlier two paragraphs only indicates that there is every scope for further improvement of the strategy in terms of its effectiveness through the process of experimentation with different components of the strategy independently with groups of students varying in their characteristics, with the presence and absence of certain aspects of the instructional component.