

DEVELOPMENT AND VALIDATION OF A COMPUTER ASSISTED INSTRUCTIONAL PACKAGE IN BIOLOGY

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Abstract

Innovations in multimedia and computer-related technology offer exciting opportunities to impart quality education to students. One of the most powerful uses of technology in education has been to tailor instruction to students' individual learning needs. Versatility of CAI to provide student paced instructional interaction in diverse array of contents with or without the assistance of a teacher makes it a unique instructional strategy that can be used to provide learning situations inside or outside the classroom. The process involves the interaction of individual students with computer which carries out multitasking: presenting the content, receiving, analyzing and acting upon students' responses like a tutor. In the present study, CAI material was developed in selected topics of Biology for class IX students. The content was divided into modules based on selected biological concepts sequentially arranged from simple to complex. During the process of receiving instruction in each module and also at the end of each module, student is asked to answer multiple choice questions. Students can't move to next module unless they master the concepts and answer all questions correctly. Validation of the developed CAI package was carried out by seeking experts' opinions and by pilot testing on a sample of 50 students so as to ensure its suitability and effectiveness in enhancing students' learning in selected concepts of biology. On the basis of the suggestions made by experts and responses of students, the CAI material was edited and finally packaged into a CDROM for its use in teaching and learning

Key Words: *Computer Assisted Instruction, Biological concepts, Development, Validation.*

INTRODUCTION

Introduction of new educational technologies has opened new vistas for educators and researchers to create new instructional designs and practices which can be integrated with education in order to make teaching learning effective for all students catering to their individual learning needs, thus bringing about a shift from teacher centered instruction to learner centered teaching learning interaction. Kadlubowski (2000) opined that as a result of newfound technological advancements both in the fields of computer technology and

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instructional technology, contemporary educational courses are designed not only to assist students to develop personal autonomy, social competence, and creative capacity and but also to stimulate appreciation of the finer things in life. Major technological innovations have brought a key paradigm shift in the way people learn. Consequently, a major change has been necessitated in the way educational materials are designed, developed, and delivered to those who wish to learn (Wiley, 2000). As multimedia teaching technologies become more widely advocated and employed in education, researchers strive to understand the influence of such technologies on student learning. Multimedia teaching technologies enable pedagogical enhancements that some believe can revolutionize traditional methods of teaching and learning. When viewed collectively, these studies reported that advanced technologies, especially multimedia instruction, which often involves introducing or enhancing the visual aspects of the presentation of course contents, created an active learning environment, improved students' performance, fostered positive attitudes toward learning complex concepts, increased communication and could be adapted to all learning styles and levels of instruction (Angadi & Ganihar, 2015).

Computer Assisted Instruction (CAI)

Computer-assisted instruction (CAI) is an interactive instructional method that uses a computer to present material, track learning, and direct the user to additional material which meets the different needs of students especially with diverse ethnic backgrounds and also of students with special needs. The automatic interaction and immediate feedback provided by the computer during CAI enables students to learn at their own pace and progress on an individual basis.

CAI, a self instructional teaching strategy also makes use of a combination of text, graphics, sound and video while presenting material. Interactive nature of the program captures the students' attention, arouse their interest and enhance their learning to increase their scores. The principles of programmed learning are being applied to computer assisted instruction (CAI) which is a self-paced instruction format where each student works his or her way through the course material, which is broken down into small steps. The computer can be used to present learning material and help students learn through a variety of techniques such as quizzes, simulations, explorations, and tests. Computer assisted instruction is effective

in improving knowledge and skill acquisition because of the availability of immediate feedback (Pridemore & Klein, 1995).

CAI is an interesting innovation in educational technology. Its marvels have been demonstrated and seem to revolutionize the whole spectrum of education. It has better flexibility and more versatility than any of the teaching machine. It can cater to the individual needs of many students at a time and record all the responses of all the pupils with reliability (Mohanty, 2001). Safo, Ezenwa and Wushishi (2013) described CAI as a new teaching and learning strategy in which the topics to be taught are carefully planned, written and programmed in a computer which could be run at the same time in several computer units and it allows each student a computer terminal. The instructions are also programmed in a computer disc (CD), this could be played in either audio or video system for the student to learn at his /her leisure time and at his/her own pace.

Relevance of CAI in Biology Education

Science education has a vast potential to prepare individuals with logical and reasoning mind who can contribute in national development in various ways. Biology being a significant component of Science is an important subject in school curriculum at all levels. Though, basically Biology deals with the study of life and life patterns of living organisms, its applied branches include Microbiology, Biotechnology, Pathology, Molecular Biology, Genetics, and Pharmacy etc. With vast number of career choices that these Biology based courses offer, a large number of students opt to study Biology at senior secondary level. In traditional Indian classroom set up, Biology is commonly taught through lecture method which is a combination of oral presentation, chalkboard work and sometimes use of static instructional aids like charts or models: which are not enough to facilitate students in understanding dynamic life processes and phenomena. Moreover, one way mode of communication which is dominant during conventional teaching provides little scope for active participation of students, thus leading them to learn passively without making much use of their higher order thinking skills like analyzing, critical thinking and logical reasoning.

Incorporating computer based multimedia material in teaching has great potential in meeting the objectives of teaching-learning process by allowing educators to present more information, more examples, illustrations, and problems for students to solve than the conventional instructional method. Haddad and Jurich (2000) explicated that integration of

modern information and communication technologies (ICTs) stimulate the students' sensorial apparatus by using sound, color and movement and make the learning process enjoyable and interesting in Science subjects.

CAI provides novel learning environments to develop conceptual understanding of biological topics as integrated use of multiple media elements such as audio, video, graphics, text, animation etc. facilitates students to understand the subject matter in depth, thus resulting in better performance. Traynor (2003) explained that CAI affects cognitive processes and increases motivation by the following ways: personalizing information, animating objects on the screen, providing practice activities that incorporate challenges and curiosity, providing a fantasy context and providing a learner with choice over his/her own learning. CAI offers several facilities that can be used to improve the teaching of biological processes. A computer enables repeated trials of an experiment with considerable ease in a limited time, provides immediate feedback, allows simultaneous observation of graphical representations and offers a flexible environment that enables students to proceed with their own plans and automatic adjustment to ability levels of students; continuous interaction and flexible time scheduling for the students and the instruction (Cotton, 2001; Kara& Yesilyurt, 2007; Ranade, 2001). CAI has been found to be an effective strategy for enhancing student's achievement and retention in Biology and Integrated Science (Biswas & Chanda, 2013; Chaudhary, 2013). CAI when used as a supplement to conventional instruction produces higher achievement than the use of conventional instruction alone (Chaudhary, 2013). CAI emphasizes the interaction between student and relative environment, which is the basic requirement of Biology syllabus (Angadi & Ganihar, 2015).

The future of computer technology is undoubtedly a powerful vehicle for changing teaching and learning in education and CAI is a promising tool to achieve cognitive objectives more effectively.

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CAI package, in twelve topics of Biology selected from the CBSE Science syllabus of class IX, was developed by the investigator with the assistance of a software expert .The main steps in preparation of CAI (Figure 1) are as follows:

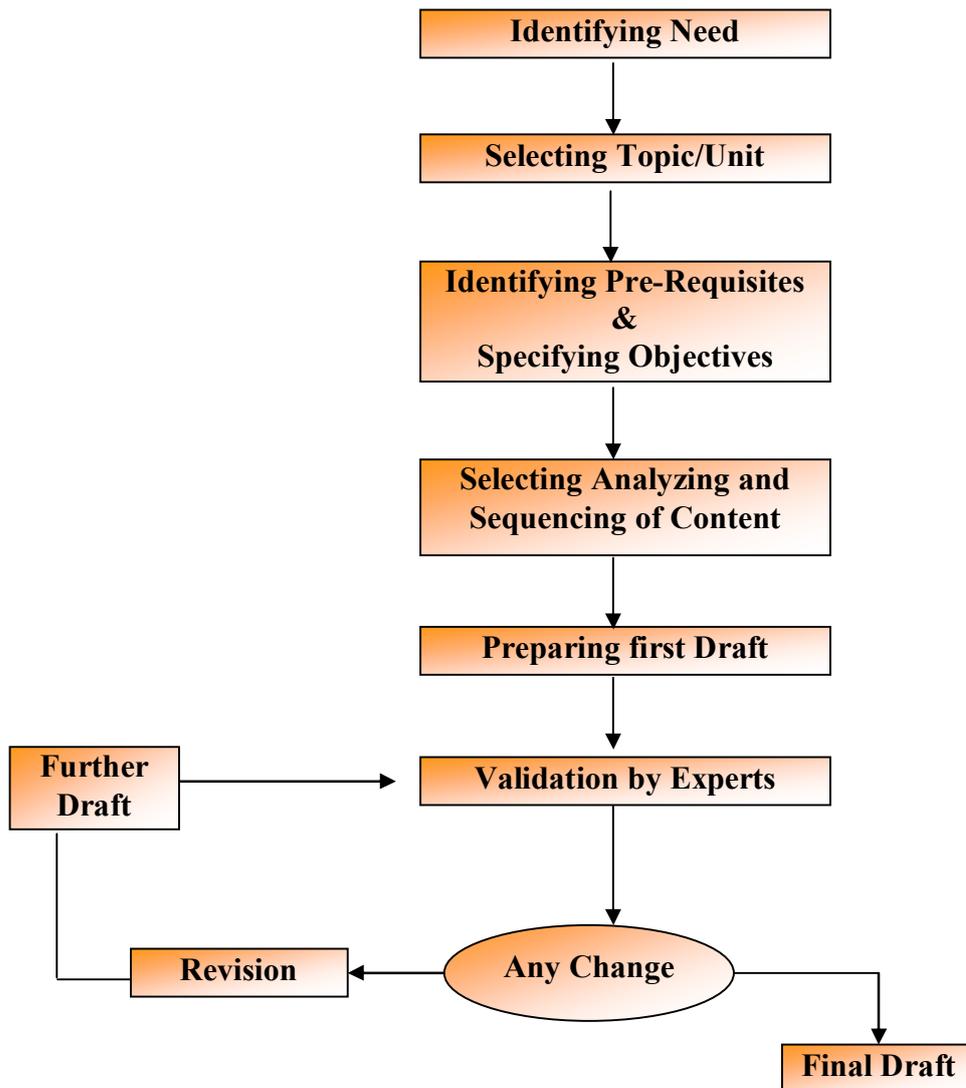


Figure 1. Format showing different steps involved in the development of CAI. (Mayer, 1984)

Identification of Need

An increased efficiency of the delivery of instructional material also makes students learn more efficiently. Taking advantage of integrating technology in Biology teaching, the teacher can create a learning environment which can meet students' individual needs and facilitate them in having deeper insights of biological concepts. Keeping the potential benefits of using CAI in mind, investigator felt the need to develop CAI package in selected biology topics for class IX.

Selection of Topics

Twelve topics of Biology (Table 1) selected from class IX CBSE Science curriculum for development of twelve modules constituting the CAI package were based on two chapters:

1. Cell-Basic Unit of Life
2. Tissues

Identification of Instructional Objectives

Instructional objectives are written for the student and they state what the student is expected to do following instruction. Objectives are specific, observable, and measurable learning outcomes (Waller, 2008). General and specific objectives for teaching the selected twelve sub topics of Biology through CAI were written by the investigator following Gronlund's approach and are presented in Table 1.

Table 1: General and Specific Objectives

Sl. No	Topics	General Objectives	Specific Objectives
1	Cell Discovery & The Cell Theory	<ul style="list-style-type: none"> ➤ Know how cells, free living cells, nucleus and protoplasm were discovered. ➤ Apply the acquired knowledge to identify cell components. ➤ Deduce that cell is the basic unit of life ➤ Understand the concept of the cell theory. 	<ul style="list-style-type: none"> • Define cell. • Name the scientist who discovered cells. • Name the scientist who discovered nucleus. • Name the scientist who first observed free living cells. • Name the scientist who coined the term 'Protoplasm. • Identify cell components from stained temporary mount of onion peel when seen under a microscope. • Identify cell components from stained temporary mount of cheek cells when seen under a microscope.

		<ul style="list-style-type: none"> • Name the scientists who propounded and expanded the cell theory. • Enlist major points of the cell theory. 	
2	Cell – Diversity & Types	<ul style="list-style-type: none"> ➤ Understand about diversity of cells. ➤ Know about the types of cells. ➤ Apply the acquired knowledge to identify different types of cells. 	<ul style="list-style-type: none"> • Define unicellular organisms. • Name a unicellular organism that keeps on changing its shape. • Define an organelle. • Identify the type of a cell on the basis of its microscopic structure.
3	Movement of substances across Cell Membrane	<ul style="list-style-type: none"> ➤ Know the structure of cell membrane. ➤ Apply the acquired knowledge to identifying structure of cell membrane from the diagram. ➤ Understand the process of diffusion across cell membrane. ➤ Draw inferences from the illustrations showing movement of substances across cell membrane. ➤ Understand the process of osmosis, exocytosis and endocytosis. 	<ul style="list-style-type: none"> • Identify the chemical substances that form the framework of plasma membrane. • Mention the role of plasma membrane that it plays due to its property of selective permeability. • Name the process by which oxygen molecules (O₂) move from the lungs into the bloodstream. • Describe the movement of water through a semi permeable membrane stretched across a chamber filled with water on its one side and salt solution on the other. • Define hypotonic, isotonic and hypertonic solutions. • Mention the function of exocytosis in cells. • Name the process referred to as ‘cell eating’.

4	Cell Structure – Cytoplasm & Nucleus	<ul style="list-style-type: none"> ➤ Know the structure of cytoplasm and nucleus. ➤ Understand the functions of cytoplasm and nucleus. 	<ul style="list-style-type: none"> • Mention the combined name given to the nucleus and cytoplasm of a cell. • Match various parts of nucleus to their structure and functions.
5	Cell Structure –Ribosomes, Endoplasmic Reticulum & Golgi Apparatus	<ul style="list-style-type: none"> ➤ Know the functions of ribosomes, endoplasmic reticulum and Golgi apparatus. ➤ Draw conclusion from given situation related to ribosomes. 	<ul style="list-style-type: none"> • Name the cell organelle that carries out the process of packaging and exporting proteins. • Name the organelle that forms the supporting skeletal framework of the cell. • Describe what will happen if all the ribosomes of a cell are destroyed.
6	Cell Structure – Lysosomes & Mitochondria	<ul style="list-style-type: none"> ➤ Know the structure of lysosomes & mitochondria. ➤ Apply the acquired knowledge to identify mitochondrion from the diagram ➤ Understand the functions of mitochondria. 	<ul style="list-style-type: none"> • Name the organelles that are popularly called suicidal bags. • Identify mitochondrion from its structure given in the diagram. • Explain why mitochondria are called ‘Powerhouses’ of the cell.
7	Plant vs. Animal Cells	<ul style="list-style-type: none"> ➤ Recall that in plants food is prepared by chloroplasts that contain chlorophyll. ➤ Apply the knowledge 	<ul style="list-style-type: none"> • Name pigment containing organelles that collect light energy to produce food. • List major differences between animal Cell and plant Cell.

and understanding of cell structure to differentiate between plant and animal cells.

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| 8 | Plant Tissues- Meristematic & Simple Permanent | <ul style="list-style-type: none"> ➤ Know the characteristic features of meristematic & simple permanent tissues found in plants. ➤ Understand how the structures of various types of simple permanent tissues correlate to their functions. ➤ Analyze the given features to identify the tissue of coconut husk. | <ul style="list-style-type: none"> • Define meristematic tissue. • Identify the feature that enables Collenchyma to provide flexibility to plants. • Identify the feature that enables Aerenchyma to give buoyancy to the aquatic plants. • The husk of coconut is made of a tissue composed of long and narrow dead cells with thick lignified walls. Identify the tissue. |
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| 9 | Plant Tissues – Complex Permanent | <ul style="list-style-type: none"> ➤ Know various types of simple permanent tissues ➤ Know the characteristic features of complex permanent tissues found in plants. ➤ Understand how the functions performed by different elements of xylem correlate to their corresponding structures. | <ul style="list-style-type: none"> • Name the tissue that conducts food from leaves to different parts of a plant • Name the elements of phloem with which companion cells are associated. • Identify the functions performed by different elements of xylem. |
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10	Plant Tissue Systems	<ul style="list-style-type: none"> ➤ Understand how different tissue systems in plants carry out different functions. ➤ Understand the structural modifications of epidermis in relation to specialized roles. 	<ul style="list-style-type: none"> • Identify the tissue systems on the basis of their characteristics features. • Mention another name for bark. • Identify the substance that makes cork impermeable. • Why do desert plants have thick waxy coating of cutin outside the epidermis? • Name the two kidney shaped cells that enclose stomata.
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11.	Animal Tissues – Epithelial & Muscular	<ul style="list-style-type: none"> ➤ Know the structure of various types of epithelial and muscular tissues. ➤ Understand how the structures of various types of epithelial tissues correlate to their unique functions. ➤ Deduce that the skeletal muscles are responsible for body movements. ➤ Draw conclusion that the most abundant organelles in muscle cells are mitochondria. 	<ul style="list-style-type: none"> • Identify the characteristic feature that best describes epithelium. • Name the epithelial tissue that forms the lining of kidney tubule • Mention the major role that stratified epithelium plays in our body. • Identify the muscular tissue that is involved in the movements of the arm. • Identify the organelles which are expected to be most abundant in human skeletal muscle cells.
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12.	Animal Tissues – Connective	<ul style="list-style-type: none"> ➤ Know the structure of various types of 	<ul style="list-style-type: none"> • Name the component of the blood that forms its liquid part.

& Nervous	<p>connective and nervous tissues.</p> <ul style="list-style-type: none"> ➤ Understand how the structures of various types of connective and nervous tissues correlate to their unique functions. ➤ Differentiate between tendons and ligaments. • Identify various parts of a nerve cell. ➤ Compare the connective tissue with epithelial tissue. 	<ul style="list-style-type: none"> • Identify parts of the bone on the basis of their structure. • Name the fat storing tissue found in animals. • Differentiate between tendons and ligaments. • Identify various parts of a nerve cell. • Identify the feature that differentiates Connective tissues from epithelial tissues.
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Selection of Content

Content was selected carefully ascertaining that it effectively met the objectives defined. While designing and developing instructional material, the content was analyzed through two types of analyses viz. task classification and learning task analysis.

Clustering of objectives into Instructional unit and sequencing of content

Based on the sequence of pre-requisite learning as revealed by analysis of the content, sequencing of content was done. General objectives to be achieved were clustered into instructional units combining similar objectives in one unit.

Preparation of CAI Material

Rough draft of the modules, for each of the twelve selected biology topics of class IX, was prepared by the investigator. The format of the interactive module is given below:

1. Introduction
2. Instructions to use CAI
3. Objectives (Learning outcomes): General and Specific

4. Entry Behaviour Test
5. Input
6. Practice Task
7. Feedback to practice task
8. Summary of Input
9. End Module Task
10. Feedback to End Module Task

CAIs were prepared on Microsoft Power Point by compiling information, images, diagrams related to the topics taken from the Science text book published by NCERT for class IX as well as from the web using the internet. Colorful relevant pictures, clip art, animations and movies taken from web were also inserted at appropriate places linking them with the concepts to be explained. In order to keep students actively involved in teaching learning process, the format of CAI was conversational. Every module comprised of self assessment test items in the form of multiple choice questions for sectional and terminal recapitulation of the concepts presented. Before seeking further information, learners had to answer a set of questions, the right response enabled them to go to next question whereas the wrong answer would make them go through the information again or was lead to remedial instruction depending upon the choice of response and then reattempt to answer the question.

Validation

After compilation and development of CAI, the same were evaluated for validation by three ways – self evaluation, evaluation by students through group testing and appraisal by subject and technical experts.

1. **Self evaluation:** The content matter of the instructional materials was checked by the investigator for factual accuracy as well as for its relevance to the objectives defined. She also checked it for its functional features like ease to use and navigate the content.
2. **Group Testing:** To check whether the developed instructional material was according to the mental level of the students of class IX and was effective in acquisition of Biological concepts, group testing was carried out on a sample of 50 students studying in two CBSE affiliated English medium private schools of Chandigarh equipped with computer facilities (Sharda Sarv Hitkari

Senior Secondary Model School, Sector 40 and Shri Guru Harkrishan Model School, Sector 38). These students went through the instructional material of the CAI package and gave their feedback with respect to relevance, sequencing and presentation of content, language, difficulty level, usability, navigation, average time needed to learn the package, etc.

3. **Appraisal by Experts:** Suggestions and comments of 10 biology teachers/experts about the developed material were taken who evaluated it for the content suitability and also for whether it incorporated essential characteristics of an effective instructional material. Language experts were also consulted to make suggestions for improvements regarding grammatical errors, spelling mistakes and difficulty level of language etc. Validation was also effected through two technical experts whose suggestions about the functional features and technical design of the modules were given due consideration.

Final CAI Material

Taking into consideration the outcomes of self evaluation, evaluation by students and appraisal by the experts, necessary modifications were made and final CAI modules were packaged into a CDROM for its use in teaching and learning.

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