PEDAGOGY OF BIOLOGICAL SICENCE PART – 2

(PONDICHERRY UNIVERSITY)

STUDY MATERIAL

UNIT -1

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UNIT - 1
Approaches of learning Biological science.

Syllabus: 5E learning model – Expository approach - Collaborative - Activity based learning approach– Concept attainment – Experiential learning– Inquiry approach.

Approaches and strategies for learning Biological Science

Teaching-learning of science is a very complex process. This process involves learner, teacher, teaching-learning materials, suitable approaches and strategies and conductive learning environment leading to meaningful learning. Learner is at the centre of learning process and teacher works as the facilitator of learning.

Approaches and strategies of learning helps us to decide how to initiate learning process to engage learners; how to transact the concept and what teaching-learning materials can be selected to make transaction enjoyable and learning meaningful. Studies show that different learners have different learning styles and learn differently. They come to the class with some prior knowledge about the natural world around them. Therefore, a teacher has to consider about various approaches and strategies of learning to cater to the learning needs and learning styles of all learners.

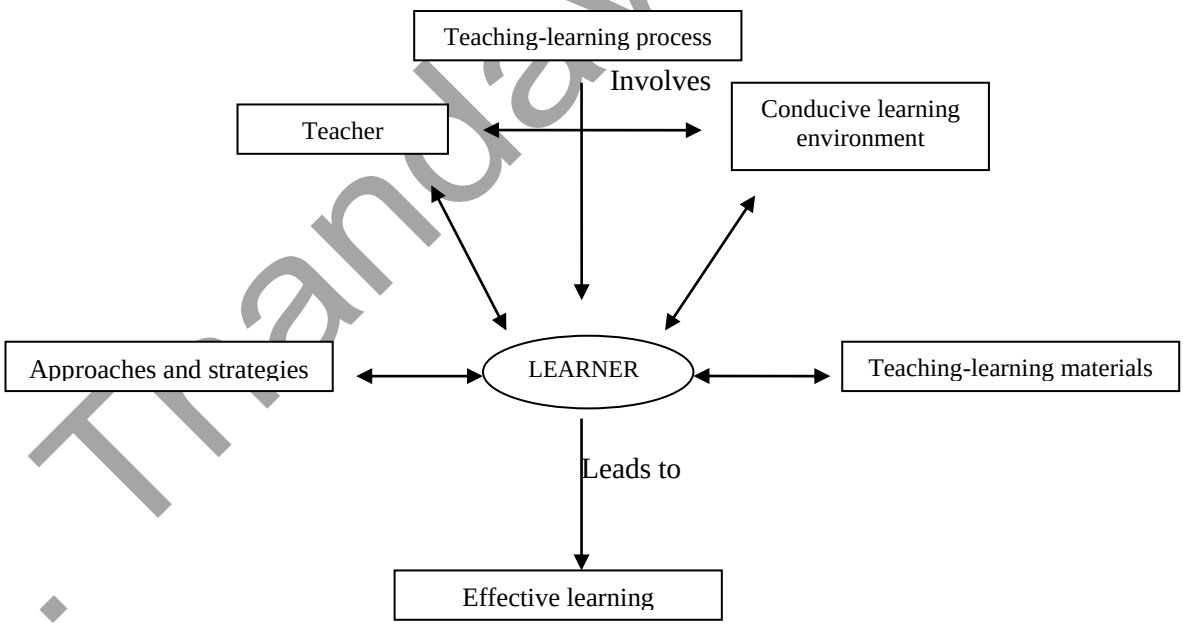


Fig. *Teaching-learning process*

Difference between approach and strategy

Approach is used in the broader sense. It means a way of thinking and working in a set direction so as to accomplish certain goals. For example, a teacher can use constructivist approach in teaching learning. This implies that whatever strategies she plans to apply will be

guided by the constructivist paradigm. She may adopt any of those innovative teaching-learning strategies and techniques that are guided by this approach.

On the other hand, strategy is a proper and systematic plan which aims to achieve the objective. *In education, strategy means selection of suitable pedagogical processes by means of using appropriate techniques, such that all of these lay in the realm of the approach, the teacher chooses to follow.* Strategies can be changed or modified depending upon teaching-learning situation. In contrast, method of teaching is a set of actions for routine way of teaching-learning. Technique is skill to engage learners in teaching- learning process. It is a certain particular way to accomplish the task/objective.

Different approaches and strategies of learning

All children are capable and eager to learn. They acquire knowledge, skills and understanding through a variety of experiences such as listening, speaking, talking, working with hands, experimenting, observing, discussing, etc. Therefore, a good pedagogy of science must essentially be a judicious mix of a number of approaches giving opportunity to all children to engage in various activities.

There are many factors which affect their learning interest, abilities, motivation and ability to apply knowledge in novel situations. Therefore, approaches of learning should suit to the needs of learners of different background.

Same concepts can be transacted by a number of approaches and strategies by the same teacher. It is also observed that the same topic can be transacted by different approaches and strategies by different teachers. Teacher is the most suitable person to decide on the approach of learning depending on the learner's previous knowledge, need of the situation, context, topic and the capabilities of the learner.

Each learner learns at her own pace and constructs her own knowledge by making her own meaning. The teacher can choose particular approach and strategy which can initiate active participation of the learners in the class.

Teacher, as a facilitator of the learning, needs to create suitable and conducive learning environment for understanding different concepts and for developing scientific attitude in different learners.

There is no best approach or strategy of teaching–learning that is applicable to all situations. Teacher needs to enter into dialogue with learners, negotiate with them, recognise

and acknowledge their existing knowledge to think about it. In order to select, improvise or invent the most suitable approach or strategy for learning science, it is important to relate it with their prior knowledge.

Selecting appropriate approach and strategy

All approaches and strategies are workable in certain situation and no approach or strategy is perfect. A particular approach may be workable in one situation, but may fail in another situation. You may think about a set of learning experiences along following lines before deciding about approach and strategy:

- Is there enough scope for involving learners, listening to them, performing activities and experiments, observing, reading, writing, discussing and guiding them for further reading?
- Does it motivate learners to learn?
- Are you comfortable with working on it? Decide about the approach and strategy yourself. Do not take it as suggested by others.
- Does it fulfill the objective of teaching-learning experiences?
- Is it workable in the local situation?

Essential Components of all approaches and strategies

The points that must be essentially considered whichever approach and strategy you select are:

- Help children learn *how to learn.*
- Recognise and understand individual differences and their learning styles.
- Be responsive and sensitive to the children's learning needs.
- Active involvement of learners.
- Inquiry and process skills of science should be integral part of teaching-learning of science. Various process skills are ability to define a problem, design an experiment, reason logically, make inferences and draw conclusions based on observations, pose questions and seek their own answers, and communicate clearly.
- Learners' previous knowledge. .
- Nature of the concept/topic to be transacted.
- Objective to be achieved.
- Availability of the resources.
- Scope of flexibility in implementing the approach.

5 E LEARNING

This is a constructivist model of teaching–learning. The (five) 5Es are - **Engage, Explore, Explain, Elaborate and Evaluate.** In this model, conceptual change can be achieved by using five distinct, but interconnected phases. Let us see it using the concept, *sound is produced by a vibrating body.*

(i) Engage: Students need to be engaged and focused on the learning tasks by asking questions, defining a problem and drawing their attention to an interesting event. This is the process of motivating to learn.

[The teacher exposes the students to various situations of production of sound by vibrating body and facilitate them to observe carefully. She draws students' attention to following situations.

- Touching the front side of the neck when singing or making a sound
- Allowing to strike a metal bowl, a bell, etc. and touching the object gently and recording their feelings.
- Watching carefully a video film on different musical instruments to know how these are played.
- Speaking her name loudly from the open end of a tin can, other end of which is covered with a stretched balloon and few pieces of grains are kept over it, and observing the movement of grains.]

(ii) Explore: Students get opportunity to explore through all senses. They are allowed to work together and build a base of common experience which assists them in the process of sharing and communicating. During exploration the students' inquiry process drives the teaching learning.

[Students observe and gain some experiences of how sound is produced in different situations. The teacher helps the students to explore what are common to all the above activities. Students observe that 'sound is produced in each case.' The teacher asks, "What is the second common thing you observe in all these situations?" They say, 'It is vibration.' One of the students asks, "How sound is produced in a table by tapping it when no vibrations are noticed in it?"]

(iii) Explain: Teacher interacts with students to discover their ideas. The communication among the peers and with the facilitator may be observed to notice their questions, writing,

drawing; and their performance of activities and experiments. This can help the teacher to facilitate progress in students' learning and integrating assessment with the teaching-learning process.

[The teacher interacts with the students and helps them to explain why they cannot notice the vibration in a table. To give the students a concrete idea that mechanical energy can produce vibration, the teacher facilitates them to perform the following two activities:

- Take a tuning fork and beat it on a hard rubber pad. Do you hear a sound? Now bring the vibrating tuning fork and dip the tip of both the prongs in a glass of water and observe carefully what happens.
- Bring the vibrating tuning fork near a table tennis ball suspended with a thread. What do you observe? The teacher facilitates them to conclude that the prongs of the tuning fork are vibrating. In some cases, the amplitude of sound is so small that we cannot see them. However we can feel them.]

(iv) Elaborate: Students are allowed to expand the concept they have learned, make connections to other related concepts and apply their understanding to real life situations. The teacher, who acts as the facilitator, helps the students to develop their understanding through additional hands-on work and minds-on activities.

[Teacher encourages the students to suggest some more activities/experiments/real life situations where sound is produced and vibration can be felt. Students share their experiences from their daily life about this concept.]

(v) Evaluate: In this stage the teacher sees if the students have attained understanding of concept and knowledge. During the teaching-learning process the teacher adopts continuous and comprehensive assessment of teaching-learning.

[Students' knowledge construction is tested through suitable questions and observation of their inquiry and process skills of science and participation in classroom activities. The teacher assesses each part of the activities involving students in formulating learning indicators and tasks specific to learning indicators. She also facilitates peer assessment and self-assessment of students. Using a rubber band, a pencil box and two pencils, students perform an activity to observe that sound is produced by a vibrating body.]

EXPOSITORY APPROACH

Students are being told (**expository learning**), what they need to know. However, **expository instruction** goes beyond just way that allows students to easily make connections from one concept to the presenting students with the facts. It involves presenting clear and concise information in a purposeful next. **Expository instruction** involves an organized **teaching method** where information is presented in a specific order. This helps to keep your focus and attention, and lays out all of the information you need to know in a way that helps you to remember it.

Expository teaching strategy is basically direct instruction. A teacher is in the front of the room lecturing and students are taking notes. Students are being told (expository learning), what they need to know. However, expository instruction goes beyond just presenting students with the facts. It involves presenting clear and concise information in a purposeful way that allows students to easily make connections from one concept to the next.

The structure of an expository lesson helps students to stay focused on the topic at hand. Often times, when students are discovering information on their own, they can get distracted and confused by unnecessary information and have difficulty determining what's important. This is why expository instruction is one of the most common instructional strategies. Most educators believe students learn new concepts and ideas better if all of the information they need to know is laid out before them.

Expository teaching is a teaching strategy where the teacher presents students with the subject matter rules and provides examples that illustrate the rules. Examples include pictorial relationships, application of the rules, context through historical information, and prerequisite information. Examples are provided to give contextual elaboration and to help students see the subject matter from many different perspectives.

In expository teaching teacher gives both the principles and the problem solutions. In contrast to his role in discovery learning, the teacher presents the student with the entire content of what is to be learned in final form; the student is not required to make any independent discoveries. The usual verbal instruction of the lecture hall exemplifies expository teaching. It is sometimes called deductive teaching because the teacher often begins with a definition of concepts or principles, illustrates them, and unfold their implications.

Asubel believes that the reason for the lack of research in is that expository teaching has been identified with rote learning. The students, presumably, can only memorized the lectures by constant review and repetition. Indeed, it is possible to present a body of material so poorly that unless the students commit it to rote memory (as in the case of nonsense syllables), they have no way of remembering it. Expository teaching, however, can present a rich body of highly related facts, concepts, and principles which the students can learn and transfer. Textbooks are examples of expository teaching, and, as you very well know, they can vary in their methods of teaching subject matter and in their organization of that subject matter.

As in the case of discovery learning, it is probably difficult to find pure examples of expository teaching. In most classes we find a combination of lectures (or teacher explanation) and discussions or lectures and laboratory and field work. In these situations, although most of the instruction is under the direct guidance of the instructor, much of it is the most or less independent effort of the student.

Expository Teaching Procedure

Expository teaching is a lecture, presentation or telling strategy used during instruction. The teacher is in control of presenting the subject matter and directs the students through the lesson. A rule is presented with an example and then practice is provided. The teacher focuses the students' attention on the key points of the subject and may use graphics, diagrams, or other representations to elaborate on the subject.

Generally the expository teaching begins with an introduction and overview of the topic before providing more specific information and detail. This expository strategy sets up the lesson and prepares the students for what's to come. By moving from the general to the specific, it allows students to understand the increasingly detailed explanations of the information and link those explanations to information that was presented previously as part of the general overview.

Instructional Strategy is designed to assist students in the acquisition of relatively factual material. This technique is facilitated by the use of pre-instructional verbal statements or advanced or conceptual organizers and the sequencing of the content. In the hierarchically arranged sequence, global, overarching concepts and principles of the discipline are presented first in the advanced organizer.

Expository teaching technique works-

(1) A statement in advance of the instruction (the advanced or conceptual organizer) is provided to the Students

(2) The content is presented in a hierarchically arranged sequence in which the global, overarching concepts and principles are presented first.

The conceptual organizer presents the content at a higher level of abstraction, generality, and inclusiveness than the content of the lesson. It is then followed by a progressive differentiation of ideas or details, concurrently integrating the new ideas with previously learned material. The explanations and clarifications made subsequent to the conceptual organizer are usually deductive arguments.

Another aspect that the expository teaching strategies have in common is that they provide transitions and sometimes a storyline to lead you through the lesson. Expository instruction involves an organized teaching method where information is presented in a specific order. This helps to keep your focus and attention, and lays out all of the information you need to know in a way that helps you to remember it. Once all of the new information has been presented, lessons typically end with a summary. The summary serves as a quick review and points out the most important facts to remember.

COLLABORATIVE LEARNING APPROACH:

One of the most important goal of education is to prepare learners for the world of work. Requirement for the world of work are exploring and developing one's own ability to:

- work collaboratively;
- communicating effectively and convincing others with one's own idea; and
- Critical thinking and problem solving skills.

In the traditional way of teaching-learning, teacher passes on the information to learners, who passively listen, mechanically jot down the notes and vomit out the received information in the examination.

In CLA, learners take responsibility of their own learning. It promotes self-learning skills in them. They have to discuss their ideas with their group members, relating it to their previous experiences. Teacher facilitates situations for active participation in teaching-learning process by encouraging collaboration among the learners. She communicates the goal to be

achieved within a limited time frame realising and respecting diverse needs of the learners and their different styles of learning. **Collaborative learning approach develops both academic and social skills in learner in an integrated manner.**

In the construction of knowledge, social aspect is also involved in the sense that knowledge needed for a complex task can reside in a group situation. In this context, collaborative learning provides room for negotiation of meaning, sharing of multiple views and changing the internal representation of ideas to the external reality. In the collaborative set-up, each learner individually and socially constructs meaning as she learns.

Collaborative learning enhances motivation to learn and increases depth of understanding. In the group setting, learners develop a positive attitude towards the learning and materials on which they work on, as they contribute to it. Learning is more effective as students themselves take care to resolve any conflicting observation and opinion. It also gives them opportunity to apply the concepts in real-life situation and to learn to solve a problem through multiple ways. Disinterested students readily learn from their peers as their learning problems and issue are better appreciated by the peers.

Working in a group, students move beyond the caste, creed, and region and get opportunity to develop friendship with each other. Students learn the qualities of doing collaborative and team work, patience, persistence of effort, completing the task within a set time frame, and sense of belongingness to the group as well as to their learning. They get to know who they are in the opinion of others and identify their own social and academic potential.

Steps of Collaborative Approach:

- Problem, issue or concept is identified to be dealt with in a group situation. It may be small or big, simple or complex, depending upon learning environment and teaching-learning process.
- Formation of groups (say 3 to 6 students) is facilitated by the teacher. Students are also facilitated to take up the task of their choice.
- There is exchange of ideas, discussion on the issue at hand or performance of activities or experiment to clarify the concept in group situation. Sharing of ideas facilitates visiting and revisiting the concepts.
- Teacher facilitates their interactions directed towards the set goal within stipulated time frame.

- Learning evidences are assessed throughout the teaching learning process and feedback is provided to all groups of the learners.

Ensuring meaningful learning through CLA

- ❖ Ensure that the group is heterogeneous. There should be learners learning with different paces and styles in a group.
- ❖ However, keep grouping pattern flexible and consider the choice of learners also.
- ❖ Every time keep on changing the members of the group.
- ❖ Facilitate them to form group rule. If there is a disagreement, consensus should emerge.
- ❖ Make it a point that group leader will facilitate the work of the group and keep them organised. The leader should not dominate over other members.
- ❖ Tell one student of the class to pass on the name of group members and group leaders on a piece of paper for your record.
- ❖ While assessing, you may give same grade to all members of the group as far as possible. This will prompt the learner learning with greater pace to motivate other learners to perform.
- ❖ It will be convenient for you if you start this approach after 2–3 months the session starts. It will give you enough time to identify academic and social skills of all the students and help you to facilitate them in forming the group.
- ❖ Ensure that members of all groups should be made responsible for their work. All members should remain open to each other's idea and get equal opportunities to share their ideas and work (Fig).

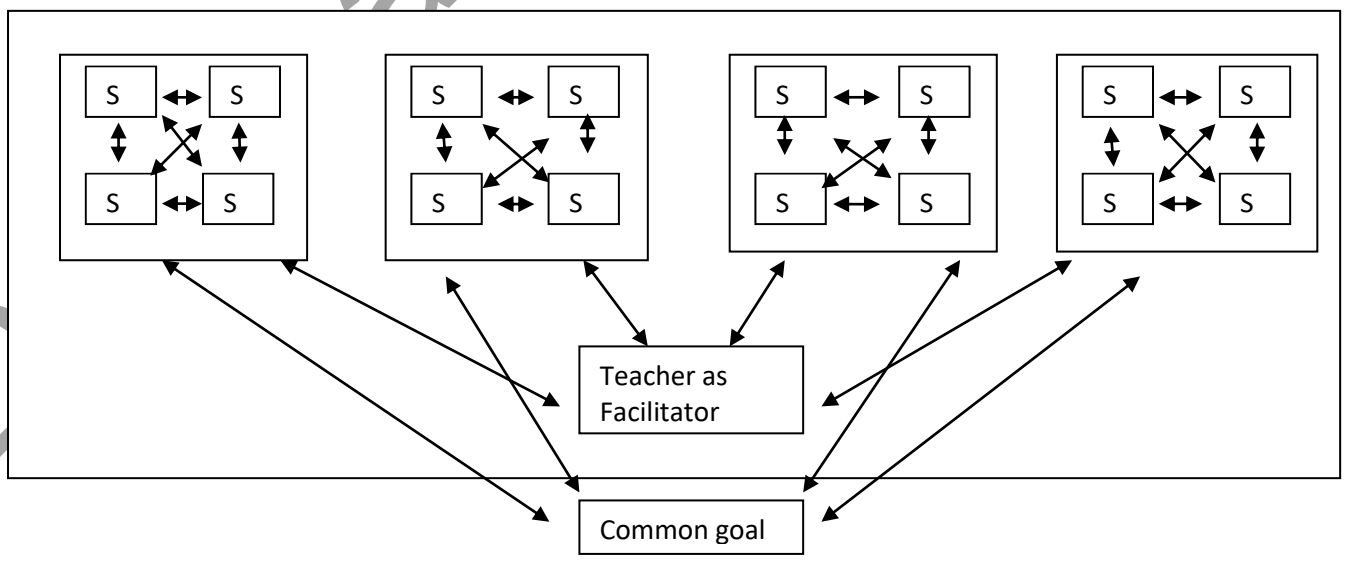


Fig : *A collaborative learning set up in classroom*

- ❖ All members should be given liberty to express their ideas freely and work cohesively towards achieving the goal.

Ways of applying collaborative learning approach

There are various ways in which collaborative learning approach may be applied such as given below.

(i) Brainstorming

- ➢ A problem is identified.
- ➢ Small groups are formed.
- ➢ All members are encouraged to find the solution and express their ideas.
- ➢ No idea is criticised. However, ideas can be modified.

Example: How can we minimise wastage of water? *Skills developed:* Generating ideas, creativity.

(ii) Task group

- A task is identified.
- Small groups are formed.
- Each group of the class is assigned a specific task to be completed within a time frame.
- Task of each group is evaluated by other group.
- Completion of task is responsibility of all.

Example: Prepare models of lever of Classes I, II and III. *Skills developed:* Taking responsibility, delegation of work, imitativeness, planning skills, accomplishment, evaluation and emotional skills.

(iii) Inquiry group

- ❖ Teacher creates a situation of some discrepant event during teaching-learning process.
- ❖ Students are helped to realise that there exists a problem, solution of which is to be inquired.
- ❖ Different groups work on the same problem and may come up with different hypothesis, solutions and conclusion.
- ❖ In order to get involved in the inquiry, learners may discuss, share their ideas, derive the equations, perform an activity, experiments and solve numerical.

Example: How would our life be affected if force of friction suddenly vanishes?

Skills developed: Problem solving skill, inquiry skills, analysis, synthesis and evaluation.

(iv) Tutorial group

- Teacher facilitates formation of group according to students' ability.
- A concept is identified by the teacher which can be learned in a group setting.
- A student having good understanding of the concept is identified as group leader by the teacher. Opportunity should be provided to various students in turn.
- The group leader is assigned the job of facilitating learning to all members of her group.
- The group leader asks questions with the members and encourages them to discuss their learning difficulties with her.

Example: Determine unknown resistance using a meter bridge. *Skills developed:* Basic competencies related to a concept develop in all members.

There is a difference between cooperative learning and collaborative learning. In the former set-up, the centre of authority is the teacher, the group is held responsible for collective learning. However, the collaborative learning encourages self-governance, shouldering responsibilities according to one's interest and skill. Each member is accountable for the task. It is convenient to use former setting when a task can be done by one way only, e.g. learning formuale or writing or chemical equation as given in the textbook. Solving a problem, doing experiment/activity/project demands collaborative set-up.

Limitation of collaborative learning approach

- Teacher's dominance is reduced. The control is passed onto the students themselves. As a result, some teachers may feel like loosing control.
- If work of the groups is not properly monitored, misconception and naive concepts may breed in the thinking of learners.
- A few shy students may not participate actively in the group. Interaction of all members needs to be continuously monitored.
- It may be difficult to check and recheck the work of all the groups working at one time for an inexperienced teacher.
- Very meticulous planning is required for meaningful learning to take place. Various aspects need to be considered— needs, interest and abilities of each student, scope of the

activity/concept to be discussed in the group and classroom management, group dynamics of the class, etc.

Active-based learning

Activity-based learning or ABL describes a range of pedagogical approaches to teaching. Its core premises include the requirement that learning should be based on doing some hands-on experiments and activities. The idea of activity-based learning is rooted in the common notion that children are active learners rather than passive recipients of the information. If the child is provided the opportunity to explore by their own and provided an optimum learning environment then the learning becomes joyful and long-lasting. The **active learning** process produces the students on having a lot more creative thinking by implementing into their basic skill of talking, listening, reading, reflecting as well as writing.

The philosophy of ABL finds its antecedents in the common notion that learning can be done best when it is initiated by the surrounding environment and motivated by providing optimum opportunities to learn. A fearless environment and freedom to express always adds to the learning outcomes. Activity-based Learning helps students express and embrace their curiosity. Once *Let the child explore and learn* the students become curious, they tend to explore and learn by themselves.

Under Activity Based learning education main focus is on the child or we can say that it is one of child-centered approach. It develops self-learning skill among the learners and allows a child to study according to his or her skill. Activities here can be in the form of songs, Drawings, Rhymes, Role play to teach a letter or a word, solve mathematical problems, form a sentence, understand social science or even concept of science. If a child is absent even a single day he starts from where he left unlike in the old system and the child had to do self-learning of the missed portions.

The key feature of the Activity Based Learning (ABL) method is that it uses child friendly educational aids to foster self-learning and allows a child to study according to his or her aptitude and skill. ABL serves as one model of child centered, child-friendly education, which is the mandate of the Right of Children to Free and Compulsory Education Act (RTE) Act in India.

The Sarva Shiksha Abhiyan Scheme by Government has introduced many initiatives and creative methods to bring about changes in teaching method for both- Teacher as well as

learners. In the state of Tamil Nadu, the elementary schools have taken the initiative to use methodology called Activity Based Learning through Sarva Shiksha Abhiyan.

Under the system, the curriculum is divided into small units, each a group of Self Learning Materials (SLM) comprising attractively designed study cards for English, Tamil, maths, science and Social Science. When a child finishes a group of cards, he completes one "milestone". Activities in each milestone include games, rhymes, drawing, and songs to teach a letter or a word, form a sentence, do maths and science, or understand a concept. The child takes up an Exam Card only after completing all the milestones in a subject. On a common chart, the milestones are arranged in the form of a ladder and the child knows exactly which milestone he completed in the last lesson.

This is a child-friendly way to evaluate and reinforce learning. If a child is absent one day, he/she continues from where he/she left unlike in the old system where the children had to learn on their own what they missed out on. Activity-based learning is closely related to Experiential Learning and Personalised Learning.

CONCEPT ATTAINMENT

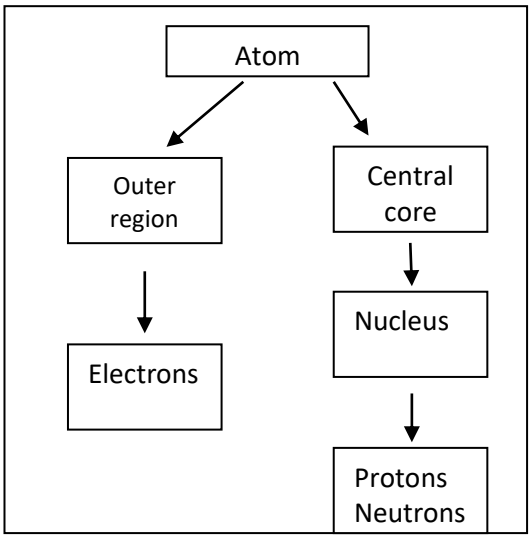
Concept maps are graphical tools for organising and representing knowledge about certain concepts. A concept map represents an understanding of the relationship and hierarchy between important set of concepts. They promote meaningful learning in science. This can be understood by studying the following components of a concept map.

(i) **Concept:** Concept may be thought of as a mental framework of an event or an object. Any event or object is a concept because it has some identifiable properties or ideas associated with it. In addition, a concept also has a label (name).

For example – A 'ball-point pen' is a concept because it has certain properties, i.e., it is long; it has a refill and it is used for writing. Also it has this label 'ball-point pen.'

In a concept map, concepts are usually presented enclosed within a circle or a box. The first step is to identify and enlist various key concepts in the topic. These concepts are then arranged in a two dimensional array hierarchically in descending order, i.e. the more general concepts are placed at the top followed by the less inclusive concepts. Concepts occurring at same level of observation are placed at the same horizontal level.

For example – For transacting the topic *Structure of atom*, the arrangement of the concepts can look like the one given in Fig. a,b



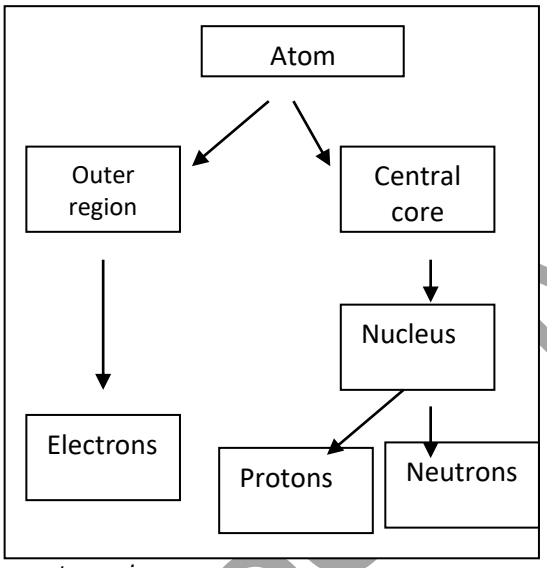


Fig. *(a), (b) Formation of concept map in process*

(ii) **Linkages:** They are usually represented by arrows or lines. They link two concepts appropriately.

(iii) **Labels for linkages:** The label for most linkages is a word/s or a phrase— although sometimes we use symbols such as +, –, x or ÷ for linkages in mathematics. Labels highlight the relationship between two concepts (Fig.). **These labels for linkages are also named as proposition.** Two or more concepts can be cross linked, if significant relationship exists between them.

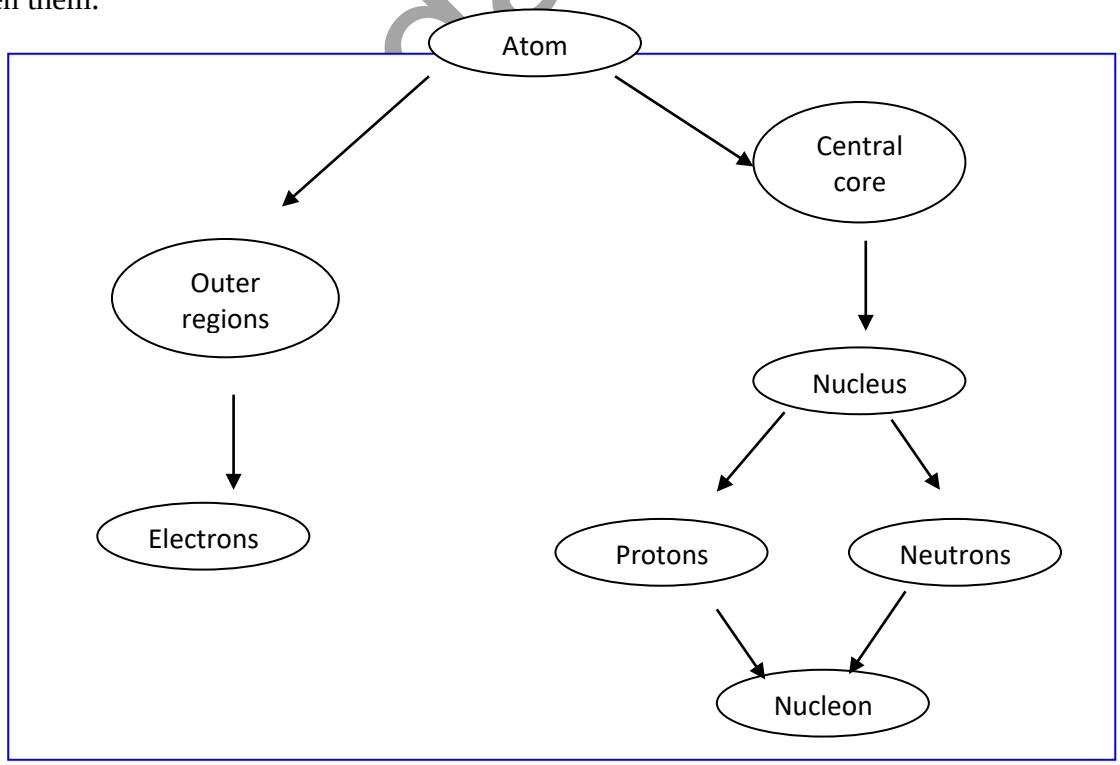


Fig. *A concept map*

Thus, we observe that concepts in a concept map are not isolated collection of the concepts. They are interconnected together through well labelled linkages. Cross-links are particularly powerful connections, which form a 'web' of relevant and interrelated concepts. These links enhance the anchorage and stability in the cognitive structure of concepts rather than just connecting general concepts to specific concepts. They tend to connect different sub conceptual structure. There is no limit on the number of connecting lines. As a matter of fact greater number of connecting lines represents integrative thinking and depth of knowledge of the learner.

Concept mapping (as developed in its standard form by Novak in 1984) is considered to be an offshoot of the Ausubelian approach. Novak himself asserts: "My work and the work of my students on concept mapping has been based upon Ausubel's theory of meaningful learning (1963, 1968). It is this fundamental principle that has led our research group to search for better ways to represent what the learner already knows."

Phases of the concept mapping

Phase I: Presentation of abstraction

• Students are presented with a definition or generalisation, which is linked to their existing cognitive structure.

• Students are asked to identify various concepts and sub-concepts and enlist them.

• Students' understanding of these concepts is assessed by asking them to provide new and unique examples.

Phase II: Propositional phase

• The teacher uses prompts and cues to guide the learners to arrange the concepts hierarchically with the broader/general concepts at the top and the less inclusive concepts at the bottom, giving the whole structure the look of a pyramid.

• The various concepts are interlinked logically by using (arrowhead) lines.

• These lines are supplemented by word/words/phrases, which define them and illustrate meaningful relationships between the various concepts.

• The whole concept map is viewed as a network of concepts.

Phase III : Application

The learners apply their knowledge to generate new examples and reflect on the existing ones.

Phase IV : Closure

The learners summarise the major ideas evolved during discussion (Fig.).

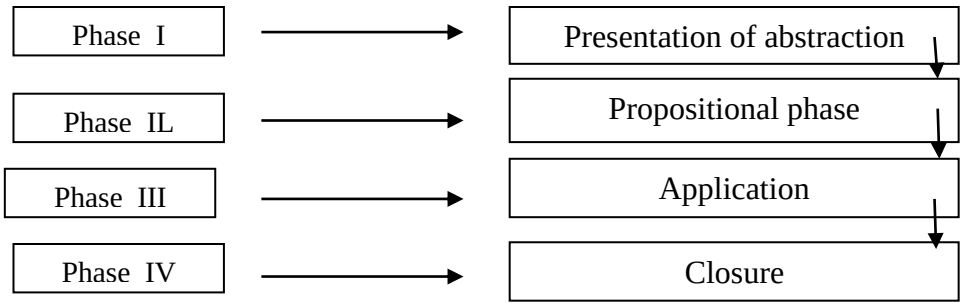


Fig. *Phases of Concept Mapping*

Uses of concept maps

The potential of concept maps needs to be explored in our schools as they are of tremendous use for learners, teacher, curriculum developers and evaluators. Some of the uses of concept maps are highlighted here.

(i) **For learners:** Concept maps can be used by learners for meaningful acquisition of concepts. This can be accomplished through various mechanisms, such as:

- Providing a visual representation of a particular material (e.g. text material). This helps the students to make better sense of the material, especially when the material is complex. A conceptual framework can be provided to elaborate on the key concepts.
- Helping learners develop new relationships among concepts in one or more related areas, thereby creating new meaning.
- Summarising material when preparing for examinations.
- Motivating learners to think and engage in active learning as they try to construct the most plausible relationships.
- Helping learners identify gaps in their knowledge.
- Making learners aware of the explicit roles that language plays in the exchange of information.
- Promoting reflective thinking associated with pushing and pulling of concepts, putting them together and separating them again.
- Allowing learners to exchange view, thereby achieving shared meaning, which is possible, because concept maps are explicit.
- Analysing an activity and an experiment in terms of procedure or content and reduce subsequent burden on working memory.

- ❖ Providing practice by using specific concept labels which act as attention catchers especially for students struggling to learn.
- ❖ A study (Prabha, 2005) shows that concept mapping as a teaching-learning strategy can be applied to facilitate learners to draw the ray diagrams of the formation of images by the lens and mirrors for different position of the object. It provides a holistic view of the phenomena of reflection and refraction of light.

(ii) **For teachers**: Concept maps may serve teachers in several ways such as:

- Helping in planning a lesson by identifying key concepts, their prerequisites and relevant examples.
- Serving as a means for providing an overview of some unit.
- Providing an operational definition of a teaching-learning goal by indicating the learning objectives that are to be attained.
- Serving as a remarkably effective tool for helping learners to identify their alternative framework (misconceptions and naïve concepts).
- Helping in planning interdisciplinary teaching-learning by developing a conceptually coherent programme that integrates concepts from different areas.

Thus, Construction of concept maps may be provided as an activity prior to a lesson to reveal previous knowledge of the learners; as homework; for consolidation; to summarise and review the lesson; in a group discussion; as an individual assignment in evaluation, etc.

(iii) **Concept maps as effective tools in complex laboratory environment**: The connection between theoretical concepts and experimental observations can be considered as criteria for meaningful learning of scientific concepts in complex laboratory environment. New experiments can be designed to understand integration and linkages with the theoretical part of the concepts using concept maps. Concept maps can also be created as a part of post-laboratory activity.

EXPERIENTIAL LEARNING

[Ashok is a student of class VIII. He had studied about fermentation process in his class. He was told that the bread he eats has acquired porosity, because of fermentation process. He wanted to see the making of bread to understand this process. He visited a nearby bakery with his parents. After observing the process of bread making, he discussed the various steps with the bakery owner. This made his learning of the process of fermentation explicit. This type of learning is experiential learning.]

Experiential learning is the process of learning from direct experiences. However, experiential learning is not just a fieldwork or connected with learning from real-life situations. **It is a theory that defines the cognitive process of learning, emphasising the importance of developing four kinds of abilities, viz. concrete experience, reflective observation, abstract conceptualisation and active experimentation where a learner encounters some experiences.**

These four stages are suggested by Kolb & Fry (1975) and follow each other as depicted in Fig.

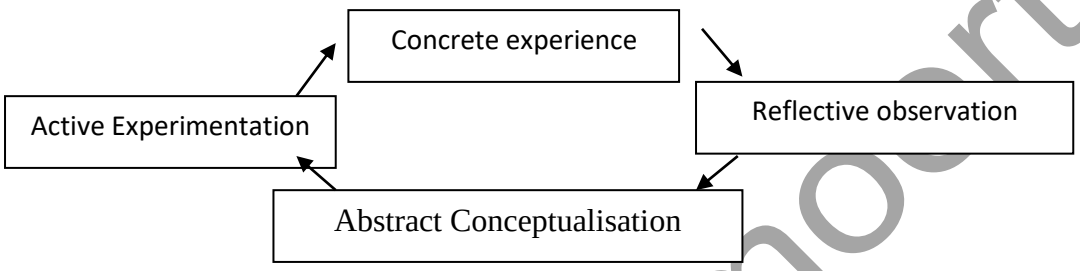


Fig. *Four stages in experiential learning*

Concrete experience is followed by reflection on that experience on a personal basis. This may then be followed by the derivation of general rules describing the experience, or the application of known theories to it (abstract conceptualisation), and hence to the construction of ways of modifying the next occurrence of the experience (active experimentation), leading in turn to the next concrete experience. All this may happen in a flash, or over days, weeks or months, depending on the topic. This complete process allows one to learn new skills, new attitudes or even entirely new ways of thinking.

Abilities of an experiential learner

Based on the four stages of his model, Kolb argues that effective learning necessitates the possession of four different abilities on the part of the learner as shown in Fig.

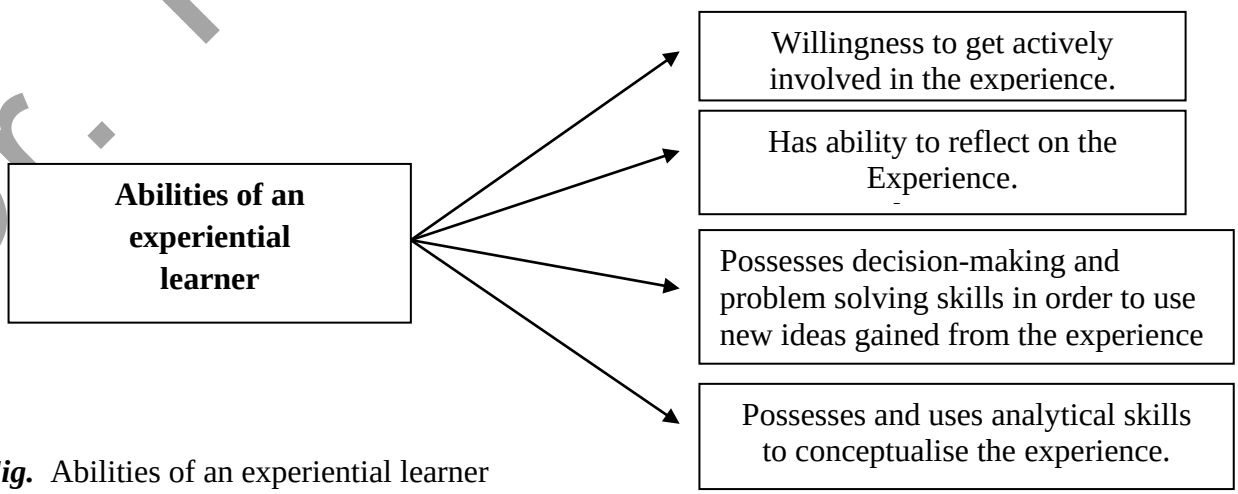


Fig. Abilities of an experiential learner

The experiential learning can take place in formal education also. One will have to develop proper strategy of planning activities and involving learners. An example in the formal system of teaching- learning can be the use of Science Park. In a science park students can play with various models and exhibits and learn the basic principles involved in them. In some cases, the learners can be engaged in survey work, conducting interviews of the scientists, collecting different chemicals and materials for activities, writing assignments, etc.

Role of a facilitator

The process of experiential learning depends on creating experiences where learning can be facilitated. An excellent facilitator believes in the creed: "You teach *some* by what you say, teach *more* by what you do, but most of all, you teach *most* by who you are." And while it is the learner's experience that is most important to the learning process, it is also important not to forget the wealth of experiences, a good facilitator also brings to the situation. An effective experiential facilitator is one who is passionate about his or her work and is able to immerse learners totally in the learning situation, allowing them to gain new knowledge from their peers and the learning environment created. The facilitator stimulates the imagination, keeping learners hooked to the experiences.

INQUIRY APPROACH

Inquiry-based learning is a form of active learning that starts by posing questions, problems or scenarios. It contrasts with traditional education, which generally relies on the teacher presenting facts and his or her knowledge about the subject. Inquiry-based learning is often assisted by a facilitator rather than a lecturer. Inquirers will identify and research issues and questions to develop knowledge or solutions. Inquiry-based learning includes problem-based learning, and is generally used in small scale investigations and projects, as well as research. The inquiry-based instruction is principally very closely related to the development and practice of thinking and problem solving skills.[

In the above teaching-learning approach you find that teacher does not give lecture on the types of materials/classification of materials on the basis of their properties. He created the situation in the class to make them observe, think, classify, record, conclude and communicate about the classification of materials on the basis of their physical properties.

Thus, an inquiry-based teaching-learning approach promotes exploration of ideas, experimentation and critical thinking. The inquiry should relate the real life experiences of the students to their learning process.

Inquiry approach is not just about asking and answering questions. Learners should be facilitated to engage themselves in using equipments and measuring devices to collect data and pose questions for explanation; using graphs and diagrams for communication and getting clarification of ideas from multiple sources. Inquiry begins with observation and can be carried out through reasoning, hypothesis, experimentation and activities and communicating ideas effectively to construct argument and generate knowledge.

Characteristics

- Creating questions of their own
- Obtaining supporting evidence to answer the question(s)
- Explaining the evidence collected
- Connecting the explanation to the knowledge obtained from the investigative process
- Creating an argument and justification for the explanation.

Inquiry learning involves developing questions, making observations, doing research to find out what information is already recorded, developing methods for experiments, developing instruments for data collection, collecting, analyzing, and interpreting data, outlining possible explanations and creating predictions for future study.

Levels

Level 1: Confirmation Inquiry The teacher has taught a particular science theme or topic. The teacher then develops questions and a procedure that guides students through an activity where the results are already known. This method is great to reinforce concepts taught and to introduce students into learning to follow procedures, collect and record data correctly and to confirm and deepen understandings.

Level 2: Structured Inquiry The teacher provides the initial question and an outline of the procedure. Students are to formulate explanations of their findings through evaluating and analyzing the data that they collect.

Level 3: Guided Inquiry The teacher provides only the research question for the students. The students are responsible for designing and following their own procedures to test that question and then communicate their results and findings.

Level 4: Open/True Inquiry Students formulate their own research question(s), design and follow through with a developed procedure, and communicate their findings and results. This

type of inquiry is often seen in science fair contexts where students drive their own investigative questions.

Banchi and Bell (2008) explain that teachers should begin their inquiry instruction at the lower levels and work their way to open inquiry in order to effectively develop students' inquiry skills. Open inquiry activities are only successful if students are motivated by intrinsic interests and if they are equipped with the skills to conduct their own research study.

Open/true inquiry learning …

An important aspect of inquiry-based learning is the use of open learning, as evidence suggests that only utilizing lower level inquiry is not enough to develop critical and scientific thinking to the full potential. Open learning has no prescribed target or result that people have to achieve. There is an emphasis on the individual manipulating information and creating meaning from a set of given materials or circumstances. In many conventional and structured learning environments, people are told what the outcome is expected to be, and then they are simply expected to 'confirm' or show evidence that this is the case.

Learning has many benefits. It means students do not simply perform experiments in a routine like fashion, but actually think about the results they collect and what they mean. With traditional nonopen lessons there is a tendency for students to say that the experiment 'went wrong' when they collect results contrary to what they are told to expect. In open learning there are no wrong results, and students have to evaluate the strengths and weaknesses of the results they collect themselves and decide their value.

Open learning has been developed by a number of science educators including the American John Dewey and the German Martin Wagenschein. Wagenschein's ideas particularly complement both open learning and inquiry-based learning in teaching work. He emphasized that students should not be taught bald facts, but should understand and explain what they are learning. His most famous example of this was when he asked physics students to tell him what the speed of a falling object was. Nearly all students would produce an equation, but no students could explain what this equation meant.

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