

Participatory Approaches in Teaching Sciences

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Abstract

In the wake processes of globalization and liberalization, working environments have been undergoing fast changes to accommodate themselves with knowledge explosion. To cope with the challenges of knowledge explosion in the science and technology, the teachers need to adopt participatory approaches that teach the students the art of learning and learning to learn.

The present paper reflects the various participatory approaches that a teacher can use in the teaching of science.

Introduction

The word science is taken from the Latin word 'Scientia' which means knowledge or to know. Science is referred as an organized or systematized body of knowledge. To the founding fathers, the meaning of science was 'To know God better, know His works.' Later the study and exploration of the working (laws) of nature became a passion that has driven all scientists ever since. According to modern thinking, the curiosity of man to know about himself and his surroundings has led to an accumulation of a vast body of knowledge, called as Science. Today, science is an amalgamation of observation, identification and theoretical explanation of the phenomenon that occurs in nature.

According to Einstein, "Science attempts to make chaotic diversity of our sense experience that corresponds to logically uniform system of thoughts." Fitzpatrick has defined science as a cumulative and endless series of empirical observations which results in the formation of concepts and theories, with both concepts and theories being subject to modification in light of further empirical observations. Science is both a body of knowledge and the process of acquiring it. Thus, science is one of the activities that human beings have created to address needs, interests and desires. It is a disciplined way of knowing as well as seeking new knowledge.

Branches of Science

There are pure and applied branches of science but for the convenience, science is divided into the following three branches. (However, in recent times many new fields have emerged.)

- **Physical sciences:** These include Physics, Chemistry and Astronomy. Physics is the study of matter, energy and interaction between them. Chemistry is the science, which deals with composition, properties, reactions and structure of matter. Astronomy is the study of universe beyond Earth's atmosphere.
- **Earth Sciences:** These include Geology, Paleontology, Meteorology, and Oceanography. Geology is the science of origin, history and structure of earth, whereas, Paleontology is the science of life forms, which existed in prehistoric or geologic period. Meteorology deals with atmosphere and its phenomenon and Oceanography is the study of oceans. Environmental science is also one of the earth sciences.
- **Biology or Life Sciences:** Botany, the study of plants, and Zoology, the study of animals constitute the life sciences.

Thus, science unfolds the mysteries of life and universe and has influenced the existence of man largely, be it vocational, social, political or cultural aspects.

Science education and its needs

Science is the knowledge and understanding of scientific concepts and processes required for decision-making, participation in civic, cultural affairs and economic productivity. People who are scientifically literate can ask for, find or determine answers to questions about everyday experience. The elements of science like developing hypothesis, proposing critical experiments, making observations, collecting data, testing ideas, developing logical conclusions should be woven into every content area and become a part of life. The principal goal of science education is to create individuals who can develop creative and innovative thinking to become capable of doing new things and not just follow the past generations. Further the question: 'Why teach science?' can be answered in the light of the objectives of science teaching. They are as follows:

- To explore and interpret the physical world. (The three fundamental areas of Physics, Chemistry and Biology help in achieving this objective.)

- To acquire understanding of scientific concepts, principles and laws;
- To develop instrumental, communicational and problem solving skills ;
- To develop scientific temper, attitudes and values such as open-mindedness, intellectual honesty, suspended judgment, courage to question and respect for human dignity;
- To cultivate social, ethical, moral and aesthetic values which exalt and refine the life of the individual and the society;
- To appreciate the contributions of scientists and develop sensitivity to possible uses and misuses of science;
- To develop concern for a clean environment and preservation of the ecosystem.

The National Policy of Education (1986) has placed special stress on science education keeping in view its inherent nature. It has emphasized inculcation of traits like spirit of inquiry, creativity, objectivity, the courage to question and aesthetic sensibility along with scientific temperament. In the present era, one feels the need for an entire new approach to the process of science teaching and learning. Our world has now become information rich and technology based society. It is essential to give emphasis on 'how to learn' rather than 'what to learn'.

Science is omnipresent. It implies observing, thinking, examining and evaluating things/ objects / phenomena which can be learnt from a bicycle, from a village pond, from virtually everything around us. Yet, many of us struggle while teaching science. Science courses in schools and colleges should not be looked upon as bodies of content to be memorized but should provide opportunities for learners to develop an understanding of the principles of science and scientific method. The National Curriculum Framework 2005 has also emphasized that: 'The science teaching should engage the learner in acquiring methods and processes that will nurture the curiosity and creativity of the students in relation to their environment.' Hence, to transact the science content effectively a science teacher/ teacher educator needs to answer the following questions:

- How do I improve the quality of learning?
- How to improve the quality of teacher giving the input?

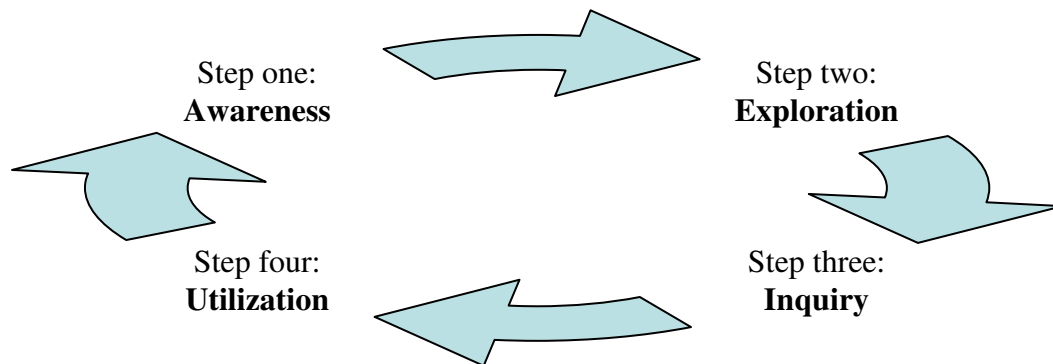
The following are the aspects, which revolve round these questions, followed by a few probable solutions.

Constructivist approach to the teaching of science:

Constructivism is undoubtedly a major theoretical influence in contemporary science. If we want to produce scientists like Newton, Einstein, Homi Bhabha, Dr Abdul Kalam, we need to make sure that the science classrooms and laboratories are actively used to construct knowledge rather than just verifying what they did. The atoms, electrons, nuclear fission, radio physics, biophysics, computers, communication satellites, etc have all become household works. Therefore, learners must be given access to the knowledge systems of science, the process of knowledge construction must go beyond personal empirical enquiry.

(Follow a pattern of presentation: For this to happen, students need to be given problems to work upon.....Give the students a problem and ask them to solve it. The students may come out with innovative ideas and solutions to the problems. In the process, they may themselves discover original facts like that of Galileo's discovery of pendulum. For instance, students could be made to put nails in different places and observe the rate at which they rusted. Thus, the theory that rusting is a chemical reaction between iron, oxygen and water, resulting in the formation of a new substance, is one that students are likely to generate for themselves. Such an approach can do a lot of service to science education by alerting teachers to the function of prior learning and extant concepts in the process of learning new material, by stressing the importance of understanding as a goal of science instruction, by fostering pupil engagement in lessons, and other such progressive matters. . In this manner, the students learn the art of 'Learning to Learn' as suggested in the UNESCO's Delors report *The Treasure Within*. In science there is no book or court or canon to which all difficulties can be referred, expect the book of nature.

The teacher can assist the students in creating new cognitive structures by designing learning experiences in a manner congruent to the natural learning process. One popular approach is the application of learning cycle, put forth by Bredekamp (1992).



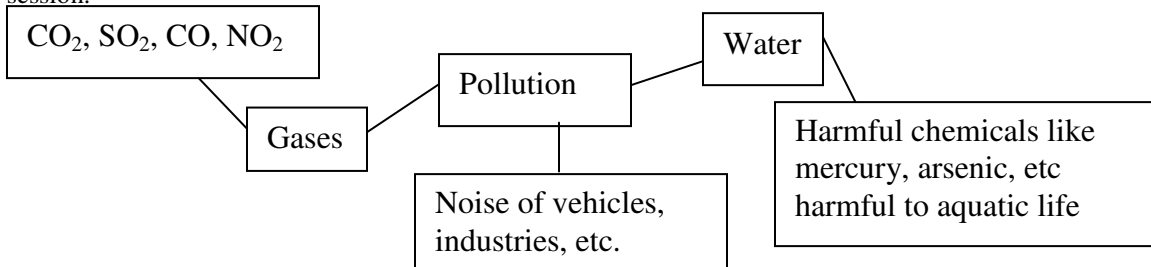
Suppose, the teacher intends to teach the concept of Acid Rain to the students. The learning cycle is followed as below.

Step 1: Awareness: The students are aware that when the humidity in the atmosphere increases the pollutant, gases mix with rain water.

Step 2: Exploration: the teacher may generate curiosity in the minds of students about the word 'acid'. Why rain is called acid rain? (Students may even mix some acid, chemicals, pass some gases like nitrogen dioxide, carbon dioxide, etc in water and so on to satisfy their curiosity.) The chemical reactions that take place here can also be studied.

Step 3: Inquiry: the students can be given access to the articles from the news paper indicating the issues of the Taj Mahal being affected due to acid rain, website reflecting information about acid rain, etc. Step 4: Utilization: the effects of acid rain on environment and measures to prevent it can be discussed here. Thus, the learning cycle can be followed to construct knowledge.

Brainstorming is one of the best methods that provide opportunities to pupils to construct their own ideas. The brainstorm with an experience web is an activity that can be assigned to the students to structure their ideas and thoughts. This activity can be better understood in the light of the following example. A student when given a topic 'Pollution' probably may construct the following web during the brainstorming session.



Some other students may construct a web more systematically indicating the types of pollution, their causes and harmful effects thereof, and even precautionary measures. Thus, this approach helps the student construct an individualized web!

Active learning and cooperative learning approach to Science teaching:

The active learning approach is one in which students brainstorm, formulate questions on their own, discuss, explain, answer questions and solve problems during class. In the cooperative learning approach, the students work in teams: on problems and projects which foster positive interdependence and individual accountability. The use of various methods that can be used are the inductive- deductive method, assignment method, lecture cum discussion method, problem solving method, laboratory method, and project method can be made here.

'Learning by doing' is a theme that many educators have stressed since John Dewey's convincing argument that children must be engaged in an active quest for learning and developing new ideas. Piaget has also stressed on the importance of experience as a requisite in intellectual development. Practical experiences in science are an important feature that needs to be taken care of. The active learning approach can be introduced in the classrooms by modifying the traditional lectures. This can be done by involving the students during the lecture by inserting brief demonstrations or short ungraded writing exercises followed by a class discussion. The feedback lecture, guided lecture, visual based instruction, group

discussions, experiments and observations, debates drama, role-playing also increase student level of engagement and facilitate learning by doing.

In the classrooms, the teacher has to develop a spirit of enquiry among the students teaching them to question the current established body of knowledge and suggest new subsidiary hypotheses to the same phenomena. Every school student knows that a freely suspended magnet points towards north and south directions. A curious student goes a step further and asks himself, "Is it true? Let me find out." Such curiosity needs to develop in the minds of the students. The teacher can help the students discover the facts like 'Organic substances like ethyl alcohol and diethyl ether has the same number of carbon, hydrogen and oxygen atoms and yet they have different properties. One is a gas while the other a liquid. Why such anomaly?' Today, such questions need to be answered in the science class. Learning by doing is not a slogan but needs to be brought at a practical application level. The science teacher of all level needs to provide practical input in doing; it may be writing about an electrical device used at home to performing experiments and projects.

For example, active learning approach and cooperative learning approach can be used while teaching the topic 'the transformation of matter.' The teacher can divide the class into groups and ask the students to observe changes in the state of matter from ice → water → vapor → water → ice and so on. Simultaneously, a discussion can be conducted and the concepts like melting, boiling, sublimation, evaporating, freezing, intermolecular forces and intermolecular space etc can be discussed. The visual based instruction can be incorporated during same the discussion. The body mapping technique is another innovation that can be used while teaching the human body. Students may be taught the digestive system and then, asked to mark the position of various organs (like stomach, pancreas, liver, etc) on a human body chart.

Such simple activities, when assigned to students, not only enhance learning, retention and creativity of students but also retain their interest in the subject.

Science teaching through Stories and Parables:

Stories and Parables are innovative ways to teach science. This approach can be understood with the help of the following example.

The teacher narrates the story of the master and his lazy donkey to the students of the seventh grade: "There was a man who had a lazy donkey. The man loaded the donkey with a bag of salt. The donkey on his way had to pass through the stream. While walking through the stream, the donkey slipped into the water. When he stood up, he felt that the load on his back now weighed less. The next day the master loaded the donkey with a bag of salt. The donkey repeated the act of falling in the water again and found that the weight of the bag reduced. He was very happy and so repeated the act every day. The master got angry and in order to teach the donkey a lesson he loaded the donkey with a bag of cotton. The donkey now repeated his mischievous act of dipping himself in water. However, this time the weight of the bag had increased. The tired donkey could not walk fast. He never repeated the act again. In this way, the master taught the donkey a lesson."

The teacher can then explain the students the various concepts in science like solubility, absorption, density, composition of the salt, cotton, water etc. The use of PowerPoint presentations and multimedia can also be made to explain the concepts.

The stories about the discovery of vitamins, periodic table, etc when narrated to the students develop logical thinking abilities in them.

The strip story approach used in language teaching can be used in science also. The story about a scientist and his attempts to invent can be written on separate strips/ paper and be distributed to different groups of students. Each group may read aloud the sentence on the strip and listens to others carefully. After reading aloud all the sentences, the group formulates their own story thereby the students creativity and logical thinking is enhances. When the stories are read, the teacher narrates the true story of the scientist and the invention respectively. This indeed facilitates the learning and retention of the knowledge.

Science laboratories and Science Kits:

Science laboratory is important in science education. Science cannot be taught effectively without testing; experiments, demonstrations of testing scientific facts and principles. In the above-mentioned approaches, the use of science laboratories is essential and provides hands on practice to the pupils. It is favorable to have a lecture room cum laboratory to make teaching learning process more interactive and conducive. For effective teaching of the various topics in the subjects' physics, chemistry and life sciences, it becomes essential to demonstrate certain experiments. The materials/ apparatus/chemicals required for performing

the experiment are available to the teachers and students in a box container, called the science kit. The physics kit, chemistry kit, and biology kit can be used in the laboratory and during classroom discussions to favor in-depth understanding of the concept taught.

Science clubs:

Students have the ability of make things, break things, handle things, and explore their surrounding but the conventional system of education does not allow them to do so. The aims of the science club are: to bring awareness about the scientific developments, to utilize the scientific concepts in common problems. The science clubs provides the opportunities to the young minds and channelize their energies to work on their own ideas, hobbies, experiment, etc.

The teachers and students can work innovately in the science club by doing the following activities:

- Holding discussions, meetings, debates, paper reading, demonstrations, contests, essay writing competitions, etc.
- Developing scientific hobbies like gardening, beekeeping, keeping pets, assembling and devising scientific toys, reading scientific literature, etc.
- The teaching of lessons through the dramatization, role playing ,etc
- Educational excursions and visits to different places of scientific interest.
- Holding science fairs, exhibition and camps annually.
- Maintaining a science museum.
- Celebration of days and general awareness programmes.
- The club may engage in the activities like making ink, soap, book polish, creams, phenyl etc thus providing vocational skills to the students.

The science clubs are thus considered as the backbone of curricular activities in schools.

Endnotes:

The teachers must provide stimulating environment that enhance the teaching learning process. Moreover, the use of Information and Communication Technology can be used in each of the above-mentioned approaches to communicate more effectively and motivate the learners to participate in classroom. The various approaches highlighted in the paper reflect that, education must not be bookish but must involve the student in the subject and the environment around. Thus, the solution to the problems in the area of science lie on concentrating more on substances rather than shadow, formulization rather than information and construction rather than verification.

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