CONSTRUCTIVIST APPROACHES FOR TEACHING AND LEARNING OF SCIENCE

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Abstract :

Constructivism is philosophical believe that advocates individual construct their own understanding of reality. The theory of constructivism is grounded on the cognitive psychology that focused how the learner constructs knowledge from experience, which is unique to each individual. Importance of constructivism in science classroom is discussed by analyzing the findings of various researches and in light of recommendation of NCF 2005. There is comparative study about conventional and constructivist science classroom. The present paper highlighted the key components for constructivist teaching-learning approaches that are crucial for practical execution constructivism in conventional classroom. In the present article an attempt has been made for practical implementation of 5E's model through example of lesson plan based on the topic; 'states of matter' in a systematic, elaborate and refined manner.

Keywords: Constructivism, science teaching, learner, 5E's model, conventional methods

Introduction

The present era is the era of 'science and technology' and we live in the 'space age'. Science and technology became an integral part of day to day life and significantly affects our modern lifestyle. We are using either product or the process of science in all aspect of our life. Therefore science education became a key component of our modern curriculum. It is a process by which we increase and refine our understanding of the universe through continuous observation, experimentation, application and verification. Science as an enterprise has individual, social and institutional dimension. It is fundamentally a means of understanding why things happen as they do. Therefore, the learning of science in schools aims towards augments the spirit of enquiry, creativity and objectivity along with aesthetic sensibility. Along with the aims to develop well defined abilities knowing and doing being; nurtures the ability to explore and seek solution to the problems related to the surrounding and daily life situations and to question the existing beliefs, prejudices and practices in society (Liversidge et al., 2010). Thus, science education is must for every child to learn as it gives an opportunity to find out how to learn?

As a science educator, one should emphasize the quality of students' understandings rather than just surface learning or their test scores. Conceptual understanding is crucial and at the same time teacher should promote conceptual learning over rote memorization. Science teachers should call attention to the process of science rather than just the content, because students who understand the process are

better prepared to acquire science content on their own (Basili & Sanford, 1991). Hence, there is urgent need to reconstruct science instruction. In a nutshell, National curriculum framework (NCF) 2005 highlighted the importance of constructivist approach in teaching at all levels of school. In response to this, the NCERT, India have also revised textbooks on these lines and have conducted teacher training programme for using constructivism based pedagogy in classroom. Most of researches in science teaching evidences that constructivist learning model is one of the successful strategy for providing meaningful learning experiences to children in science classroom (Brooks & Brooks, 1994; Johnson & Johnson, 1994). Various experimental researches have been carried out by a number of investigators and they find out that inquiry-based science activities have positive effect on students' achievement, attitudes, skills and understanding towards science in comparison to those students taught using traditional methods (Ball & Bass, 2000; Lawson, 2010). Dogru & Kalender, (2007) compared science classrooms using traditional teacher-centered approaches to those using student-centered, constructivist methods. Initially they did not find any significant difference between traditional and constructivist method but on follow-up assessment after 15 days they found that students who learned through constructivist methods showed better retention of knowledge than those who learned through traditional methods. Hmelo-Silver et al., (2007) referred several studies supporting the success of the constructivist problem-based and inquiry learning methods. In the experimental research conducted by Sridevi (2008), on VIII standard students she found that constructivist instruction significantly improve academic achievement, science process skills among experimental group. Also, reported that this approach has positive effect on scientific attitude of students'. In a review paper, Cakir (2008), discussed that increasing the number of students' laboratory activities or trendy emphasis on "hands on" were not adequate to develop students' understanding of science. For meaningful learning "minds on" notably needed. Learning for understanding in classroom requires well-designed hands on, as well as minds on, activities that challenge students' existing conceptions leading students to reconstruct their personal theories. Therefore, during constructivists learning students' conceptual knowledge evolves in time, and many misconceptions will disappear naturally as students gain expertise. Effect of constructivist approach at primary level in Indian context was investigated by Nayak & Senapaty (2011). They found that this approach is more effective than traditional instruction in promoting creativity and raising interest of learner in mathematics. Therefore, it can be inferred from above discussion that constructivism became indispensable need for modern teaching-learning process.

In the later part of this article authors try to explain the meaning and concept of constructivism then there is brief comparative study of constructivist and conventional classroom. The objective of the present paper is to discuss the essential key elements for constructivist teaching-learning that are important characteristic for constructivist classroom and not seen in conventional class. Earlier, authors have proposed a plan on constructivism for science classroom on topic 'images formed by concave mirror' for elementary students. Therefore the another important objective of authors to focus on designing and practical implementation of 5E's constructivist model by taking another example of lesson plan on the topic; 'states of matter' in more structured and advanced manner.

Meaning and Concept of Constructivism

Constructivism is learning or meaning making theory in which we construct the knowledge on the basis of our past experiences and new things we learned (Crowther, 1997). Oxford, (1997) defined constructivism as the philosophical belief that people construct their own understanding of reality, rather than assimilate a body of knowledge about one's world and environment. Thus, the constructivists believe that the meaning or knowledge we construct, about any subject matter is based upon our interactions with the surroundings. According to Fosnot, (1996), constructivism is a theory about knowledge and learning; it describes what 'knowing' is and how one comes 'to know'. The fact that the fundamental tenant of constructivism is not comprises of any external truth or knowledge; outside of a knower's experience. The constructivist epistemology assumes that learner constructs their own knowledge and creates their own understanding, based upon the interaction of what they already know, believe and the phenomena or ideas with which they come into contact. Thus constructivism focuses on knowledge construction not on knowledge reproduction. Views of about an external world may vary from one individual to other due to his unique set of experiences. It is a theory of how the learner constructs knowledge from experience, which is unique to each individual. According to constructivist epistemology, knowledge is not objective and object depended rather than it is subjective and depending upon learners' understanding about their surroundings. Four epistemological assumptions of "constructivist learning" believe that knowledge is physically, symbolically, socially and theoretically constructed (Mohan, 2010). The details are represented in Figure – 1.

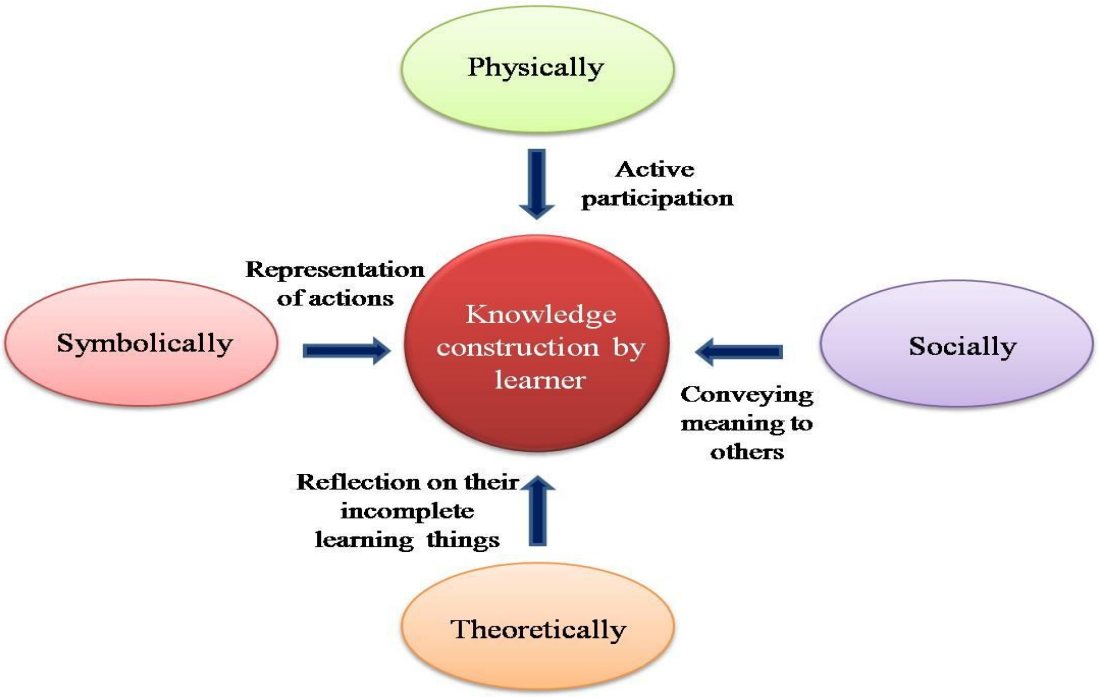

Figure – 1. Epistemology of constructivism

Thus, the philosophy of constructivism is focused on "learner" and how they construct the knowledge, therefore it has great impact to idea of "child centre approach" of teaching, which is the most important key component in contemporary educational world. Constructivist perspectives have been shown to influence the learning of students. Hence, it represents a paradigm shift from education based on behaviourism to cognitive theory. In last century, education system becomes enormously influenced by behaviourists' epistemology and major emphasis has been given on intelligence, domains of objectives, knowledge levels and reinforcement. In the present century, the learner is prime focus of all teaching-learning strategies. Many foremost endeavors worked on to make teaching-learning process 'leaner centered'. Constructivism may prove helpful in this direction, it has been adopted as learning and teaching philosophy insofar as its central themes deal with the concept of how students know and learn. It can help students to develop their abilities of lifelong learning build on their prior knowledge and experiences (Christie, 2005). Learning in constructivist framework contributes to intellectual as well as social and psychological development of learner (Kim, 2006). In fact, constructivist classroom is concealed within conventional classroom. When traditional/conventional classrooms provide sufficient opportunities to students for active participation in learning process then it represent a shift from paradigm of 'teaching' to 'learning' where learner construct and reconstruct his knowledge through meaning making process. In the constructivist classroom ample opportunities has been present for learner to observe, explore, execute, interact, raise question and discuss their views to all (Kumar & Gupta, 2009).

Conventional vs Constructivist Classroom

The traditional classroom is generally overcrowded with so many students and the single teacher has to deal with large number of students. In this conventional classroom; classes are usually dominated with 'teacher talk" and the major focus of any teacher are anyhow to cover the syllabus. They emphasized learning of answers, rote memorization, recitation of facts and bits of information and reading rather than exploration of questions, critical thinking, understanding of context and experimentation. There is very less scope for students to ask question, sharing their ideas with peer group and involve in doing experiments. As the prime focus of NCF-2005 is that the aim of school education has not only to provide bunches of information to passive students but to create learning opportunity for them and to assist them to discover the knowledge related to their surroundings. The conventional teaching practices used in class room can only stuffed the brain of children with bunch of information and failed to enhance their understanding.

Contrary to conventional classroom where classroom activities are dominated by teacher, constructivist classroom focus on students' activities. Here, teachers prepare strategy about how to organize meaningful learning environment to students where both teacher and students think of knowledge not as inert factoids to be memorized, but as a dynamic, ever-changing view of the world we live in and the ability to successfully stretch and explore that view. The chart given below compares the conventional science classroom to the constructivist one (Table-1).

Table-1. Comparative study of conventional & constructivist science classroom

Conventional Science Classroom	Constructivist Science Classroom
Curriculum It is presented part to the whole, with emphasis for inculcating basic skills among the learner. Material are primarily text book and related work books.	Curriculum emphasizes big concepts, beginning with the whole and expanding to include the part. Material include primary source of material and manipulative material.
Learning It is based on repetition. It can enhance only memory level and contribute little towards understanding of scientific concepts or enhancement of reflective thinking.	Learning is interactive, building on what the student already knows. Here, major scope for development of higher cognitive facilities like problem solving abilities, critical thinking and reflective thinking.
Teacher / Facilitator They serve as transmitter of knowledge Their role is **directive**, rooted in **authority**.	Teacher's role is shifted towards a mentor or facilitator who helps the students' in constructing their knowledge. Teacher's role is **interactive**, rooted in **negotiation**.
D. Student/ Learner Students' are the **passive recipient** of bits of information (knowledge). Learn individually	Here students are **actively** participating in on **constructing and reconstructing** in meaning making process. Learn progressively on his own under the proper guidance of teacher and interaction with peers.
Classroom environment It is authoritative and students' work competitively.	Classroom environment is democratic and students primarily work in groups.
Knowledge It is considered objective inert facts or information.	In this classroom knowledge is seen as dynamic, ever changing with individual experiences. Here, knowledge is view according to the perception of learner i.e. unique for each individual.

Comparing the characteristics of conventional science classroom with that of distinctiveness features of constructivist classroom it seem to appear that in constructivist situation provide ample opportunities to student for questioning, probing, doing own experiments and other problem solving activities. In constructivist classroom students control their own learning process and they lead the way by reflecting on their experiences. Because of collaboration in constructivist classroom student think collaboratively, discuss and share their ideas and views in peer group. When the students review and reflect on their learning process together, they reconstruct their concepts and ideas and clarify their misconceptions.

Therefore, it can be concluded that students' can learn science in better way and in true sense as according to nature of science, when constructivist pedagogy is implemented in conventional classroom. One can see significant differences in basic assumptions about knowledge, students and learning.

Key Components of Constructivist Teaching-Learning

When constructivism is employed as pedagogy for teaching and learning, then the focus tends to shift from the teacher to the students. The classroom is no longer a place where the teacher pours knowledge into passive students, who wait like empty vessels to be filled. Constructivism see of knowledge as a dynamic and social process in which learners actively construct meaning from their prior understandings and social setting (Prabha, 2010). In context of science teaching-learning process, learning of science deals with the conceptualization of science by making sense of the world around the learner and by mean of discovering theories, laws, and principles associated with reality. The constructivist epistemology assert that senses are only tool available to the knower i.e. only by seeing, hearing, smelling, testing and touching individual can interact with the environment. The individual builds a picture of world from message from these senses only (Lorsbach & Tobin, 1997). Therefore, constructivism asserts that knowledge resides in the students or learner and cannot be transferred from the head of teacher to the head of students. Important key components of a constructivist classroom in context of science teaching-learning are described below:

Leaner centered

In the constructivist model, the students are urged to be actively involved in their own process of learning. Students' opinion and ideas are accepted and encouraged. Their experiences and voices are valued. They are allowed to ask questions, make mistake and to correct those mistakes. Focus is given on what students are learning rather than what the teacher is teaching.

Learning based on students' prior knowledge

Students came in classroom with many experiences about their surroundings and natural phenomena, which may be correct or incorrect. Bookish explanation of scientific phenomena is often differing from their real life experience. In constructivist classroom this cognitive conflict of students' is appropriately handled by the teacher, who facilitates students to reconstruct their knowledge by relating it to previous knowledge via asking open ended and probing questions or concept mapping.

Interactive and cooperative classroom environment

Meaningful learning of science cannot take place by reading or memorization of facts in the science text book or just by listen the lectures of teacher it requires real talk and interaction between teacher and students (Prabha, 2010). Teacher creates interactive situations for understanding students' concepts and then refines those concepts by asking questions, posing contradictions, engaging them in inquiries.

There is ample opportunity for interaction with peer during collaborative teaching, group discussion, group assignment and project work, which are some essential elements of interactive classroom.

Process approach of learning

Process approach is method and techniques of science learning. In this approach a context is created by the teacher that helps her students to become inquisitive learner and they are encouraged to generate tentative hypotheses, making observations, collecting data and drawing conclusion. They may reject some observation and accept other observed information to arrive at correct conclusion on their own under the guidance of facilitator of learning i.e. the teacher. They learn to develop more complex thinking and reasoning skills in this context. The process of learning science is more emphasized then product of learning science.

Democratic class room

Democratic environment in constructivist classroom is maintained by sharing the responsibility in learning and decision making between the teacher and the taught. Students are directly involved in all activities of classroom. Teacher encourages their students to ask and share their ideas and thoughts freely. Students and teacher together, develop teaching aids and material. Working with concrete object they investigate scientific concepts and think critically to gain confidence in problem solving abilities (Prabha, 2010). Students enjoy the hands on experiences. Learning takes place naturally. Teacher control the class indirectly by ensuring active participation of all students in classroom activities. All these elements are crucial for creating constructivist learning environment. They are the key components for designing certain activities that can foster the students learning in science under constructivist setup.

The 5 E'S Constructivist Instructional Model for Learning of Science

In recent years, cognitive scientists and science educators have focused on the constructivist model of learning where, students' construction of knowledge can be assisted by using sequences of lessons designed to challenge current conceptions and provide time and opportunities for reconstruction to occur. There are numbers of different models of instruction are conducive to fostering a constructivist approach in the classroom. The 5 E's model proposed by Roger Bybee most widely use in science classroom. It is an instructional model based on the constructivist approach to learning, which says that learners build or construct new ideas on top of their old ideas. The each of the 5 E's describes a phase of learning, and each phase begins with the letter "E": Engage, Explore, Explain, Elaborate, and Evaluate. This model is convenient and conducive to implement in classroom situation and has considerable potential to have an effect on improvement in students' learning. This model closely follows the original format of Science Curriculum Improvement Study (SCIS), which is credited with the greatest student's achievement gains in major research studies and significant improvements in students' attitude and inquiry skills when compared to similar experimental science programmes (Sridevi, 2008). The detailed descriptions of all 5 E's are represented in Figure - 2.

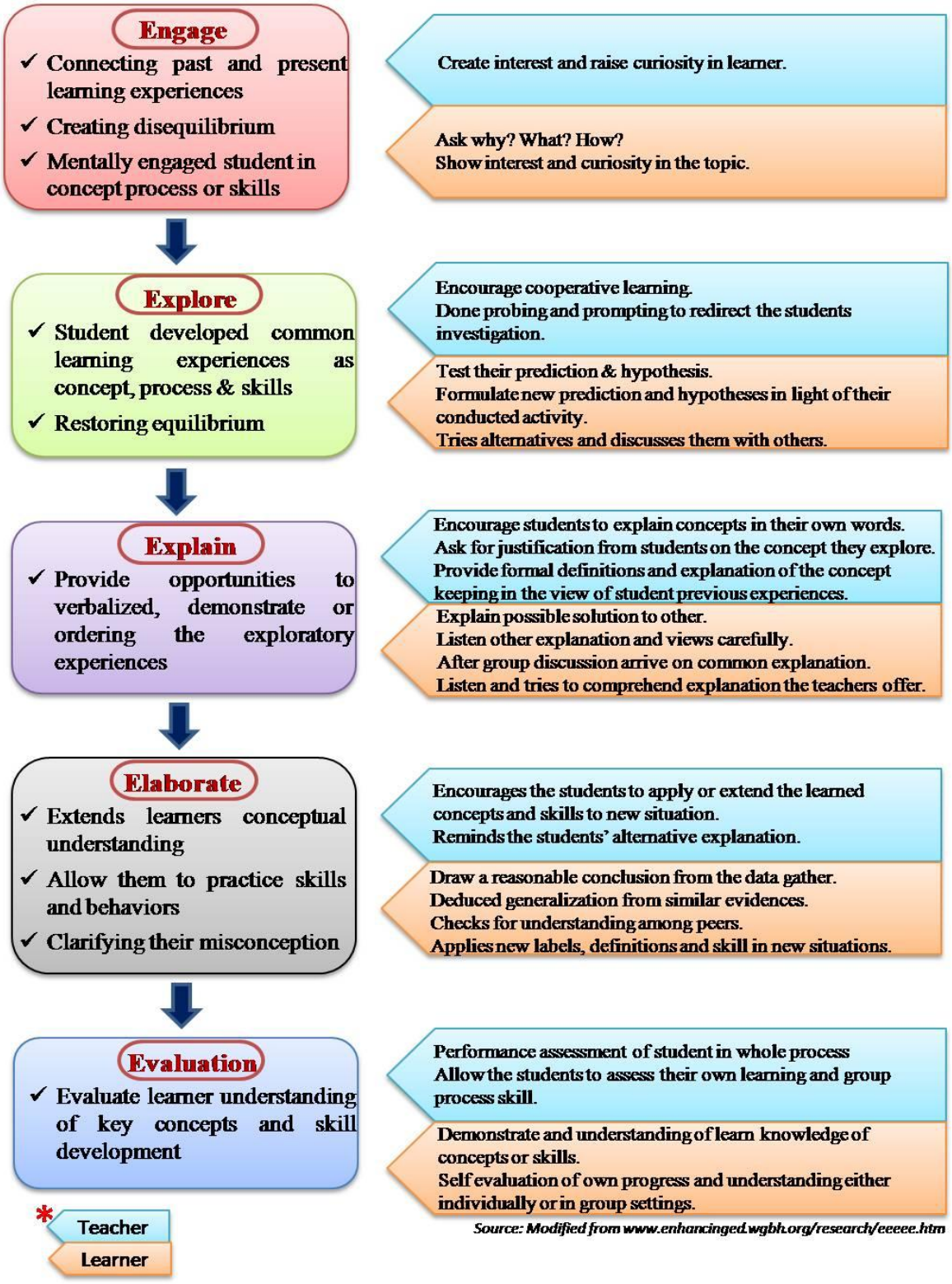

Figure - 2. Diagrammatic representation of 5Es model for science teaching represents role of learner and teacher

Constructivism is helpful in learning of science in true sense i.e., not only as a body of knowledge but also as process for making sense of surroundings. As we already discussed various research studies that illustrate the importance of constructivism in science classroom but, none of them talked about for systematic design of teaching-learning process for constructivist classroom. Therefore in the present work an attempt has been made to develop a layout for implementing 5E's constructivist model for teaching and learning of science in Indian context.

A layout / plan for Implementation of 5Es Model in Science Classroom

Content Area: Science

Topic: 'States of Matter'

Objectives

1. Students will understand the concept of different states of matter.
2. Students will observe the process of change of water in three different stages.

Key Idea: Children are familiar with the different type material/ object present in their surroundings.

Performance Indicator:

a. Students will explain the concept solid, liquid and gas.
b. Students will describe the process change in state of water in three different stages.

Table -2.A layout/plan on 5E Model *in Science Classroom*

PHASES	ROLE OF TEACHER	ROLE OF LEARNER
ENGAGE	Teacher will make the group of 4-5 students and allow them to visit and acutely observe different materials present in the school compound for 5-7 minutes including their classroom. Then, asked them to prepare a list of objects/ materials they observed. Teacher will asked the students to classify material they observed on the basis of their size, shape and some common properties.	Students will observe different type of materials and curiously prepare the list. Students will classify them on the basis of their previous knowledge.

EXPLORE	As what teacher will assess in engage phase, the explore phase will be design according to it. In case, students are not able to classify material in liquid or gaseous category then teacher will clue them by asking him to fill balloons with water and air respectively. To focus attention of learner towards properties of matters teacher can organize some activities. e.g. He will asked their students what they observe when they transfer the water from their water bottle to differ vessels like glass, beaker or bowl. And compare it with situations when coins, pens or marbles are place in different vessels or perfume will spray on it.	Students will enjoy these activities and try to find out the different properties of matters by comparing their observations in various activities. They will note their observations.
EXPLAIN	Teacher will asked each group to explain what they observed during activity and to justify their observations with proper examples. Teacher will clarify the concept of solid, liquid and gas.	The students carefully listen each other observation and explanations about the experiment and attempt to redefine his/her own understanding. Students will listen carefully try to comprehend it with their own experiences.
ELABORATE	Teacher will asked to write two more characteristics of solid, liquid and gas that has been not discussed in classroom. To apply the learned concepts new situation teacher will provide a problematic situation to them by demonstrating an experiment with ice cube. Teacher will take an ice cube allow it melt into water and then boil the water. He asked students to draw conclusion.	Students will think critically and reflect what they learn yet. Then, they will answer this question Students will conclude that ice, water and water vapors are the three different stages of water. They may also conclude that stages of matter can change.

EVALUATE	Teacher will ask questions: Explain how the solid, liquid and gas are different. Describe the change in state of water.	Students will answer these questions by giving appropriate examples.

Table -2 given above shows the role of teacher/facilitator and students'/ learner during different phases of 5E's and also summarized the different teaching-learning activities that can be organized at each step of the given constructivist model.

In the contemporary society, science and technology influence all sphere of our life. Science education is key component of curriculum and it should be taught according to nature science with an emphasis on the process aspect of science. In the present learning model emphasis is given on students/ learner not on teacher/ instructor. Here teacher only assist or guide to create proper learning situation for the active student to develop and assess their understanding and hence enhance learning. The 5 E's constructivist model used for designing experiential learning in science classroom can develop reflective thinking and problem solving skill among science students. So, authors attempt to develop a layout for designing constructivist learning in science class room for learning the concept of 'states of matters'. The implication of this innovative practice in teaching-learning process results in paradigm shift from conventional way of teaching science to designing learning science obliging in achieving the primary goal of constructivism. Keeping in the view of above literature one can infer that constructivism has very significant positive role in pedagogy of science teaching which can develop problem solving abilities, critical and reflective thinking among the students. So, that they can explore knowledge from their surrounding and logically construct and reconstruct their own understanding.

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