Research Journal of Educational Sciences _______________________________________E-ISSN 2321-0508
Vol. **4(4),** 1-10, April **(2016)** *Res. J. Educational Sci.*

Science, Science Education and Cognitive Psychology

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Available online at: www.isca.in, www.isca.me
Received 12th January 2016, revised 19th February 2016, accepted 27th March 2016

Abstract

"Everyone has two eyes but no two people view the world in a similar manner"
During the 1950s and 1960s, educator Joseph Schwab (as cited in BSCS 2009)[1] observed that science was being driven by a new vision of scientific inquiry. In Schwab's view, science was no longer a process for revealing stable truths about the world, but instead it reflected a flexible process of inquiry. He characterized inquiry as either "stable" or "fluid." Stable inquiry involved using current understandings to "fill a … blank space in a growing body of knowledge." Fluid inquiry involved the creation of new concepts that revolutionize science. In the current paper the authors would like to highlight the meaning of science through objectivist and cognitivist lens. Authors would like to present the nature of science and the processes involved in learning of science. Authors would further like to focus on how the processes, background, experience and exposure of an individual help in interpreting the same data.

Keywords: Science, Education, Cognitive Psychology.

Introduction

What is Science?: Science has been there since the beginning of human civilization in various forms. Whether it was cultivation, fishing, hunting or any other activity; one did apply some kind of logic to know and understand the phenomena. Science grew as the observation and understanding of people expanded based on the necessity. It is rightly said necessity is mother of invention[1]. Gradually, the necessity and the need to meet them grew into a body of knowledge. The body of knowledge had the processes in place that is the way of doing as well as the product.

Science can be defined as "Science is what scientist do". Scientist make descriptions, scientists make explanations and scientists make predictions.

Science is a cumulative and endless series of empirical observations which result in the formation of concepts and theories being subject to modification in the light of further empirical observations. Science is both body of knowledge and the process of acquiring it.

Science is an accumulated and systematized learning, in general usage restricted to natural phenomenon. The progress of science is marked not only by the accumulation of fact, but by the emergence of scientific method and the scientific attitude. Therefore, science is both process as well as product.

Henry Poincare[2] explains the idea this way: "Science is built of facts as a house is built of stones; but a collection of facts is no more a science than a heap of stones is a house". The true nature of science is revealed more in the way it is sought rather than in what is found, although the two efforts cannot be truly separated. Science is more of a verb than noun.

Aims and Objectives of Science

Science can be defined as "the process by which we increase and refine understanding of our selves and of universe through continuous observation, experimentation, applications and verification." Science is increasingly being viewed as a subject of life-long utility to all students, whether or not they enter science related careers. In many nations, science and technology education are becoming increasingly identified as the background for economic stability and growth. In the past, only the brighter students have been encouraged to pursue science knowledge. Science has been viewed as knowledge accessible to only the few elite. Now, however, many countries are subscribing to the goal of 'science for all'.

Science education is now major concern in almost all the developing countries. High priority has been accorded to its quantitative expansion as well as qualitative improvement. The general aim of science education is to help to develop well defined abilities in cognitive and affective domains, besides enhancing psychomotor skills. It helps to foster an uninhibited spirit of inquiry, characterized by creative, innovative and objective approaches. Therefore, science subject has its own importance and significance throughout the curriculum. Science plays a vital role in the development of many qualities in the individual's life. It helps him to be a good citizen in the society, a useful, productive and progressive member of the society intellectually enlightened, vocationally fit, morally sound and thus contributing to quality life. Realizing the importance of science education, the education commission in its report of education and national development denotes, "Science education must become an integral part of the school education and ultimately some study of science should become a part of all courses in the humanities and social sciences at the university level, even as the teaching of science can be enriched by the inclusion of some elements of humanity and social sciences."

Science education comes to closure with the secondary stage. The aim of teaching science at this stage is primarily directed towards the learning of key concepts that span all disciplines of science. At the secondary stage, the pupil should be enabled to develop a more profound understanding of the basic nature, structure, principles, processes and methodology of science, with special reference to its relationship with agriculture, industry, environment and contemporary technology. The teaching of science at this stage should help pupils to develop insights in health and environment. Greater emphasis needs to be placed on precision and accuracy while handling laboratory equipments and while engaged in procedures. It is aimed at developing scientific and technological skills and attitude among children. The following are some of the important aims of teaching science at secondary level: i. The learner understands the nature of science and technology. ii. The learner develops problem solving and decision making skills. iii. The learner inculcates the values of science and technology. iv. The learner develops transfer of skills in application of scientific principles. v. To familiarize the pupils to the world in which they live and to make them understand the impact of science on society so as to enable them to adjust themselves to their environment.

Thus, whether science is taught to the future scientist or to future citizens, there is a pressing need to ensure that the purpose of science education is changing, the content and its delivery are evolving and the expectations for students' achievement are rising. Today's students will be tomorrow's citizens. They will enter a workforce that needs the talents of better educated students, capable of life-long self-directed learning and of contributing to sound decision-making for their community and their country.

Nature of Science

Humans have always been curious about the world around them. The inquiring and imaginative human mind has responded to the wonder and awe of nature in different ways. One kind of response from the earliest times has been to observe the physical and biological environment carefully, look for any meaningful patterns and relations, make and use new tools to interact with nature, and build conceptual models to understand the world. This human endeavour is science. Science is a dynamic, expanding body of knowledge covering ever new domains of experience. How is this knowledge generated?

When we describe the nature of science, we consider the special characteristics, values, and assumptions that scientific knowledge is based on and how scientific knowledge is developed.

Characteristics of the nature of science

Science education has defined tenets (characteristics) of the nature of science that are understandable by students and important for all citizens to know. William McComas and Joanne Olson (cited in McComas edited book)[3] analyzed recent science education curriculum documents worldwide and identified 14 statements about the nature of science that are common to most curricula: i. Science is an attempt to explain natural phenomena. ii. People from all cultures contribute to science. iii. Scientific knowledge, while durable, has a tentative character. iv. Scientific knowledge relies heavily, but not entirely, on observation, experimental evidence, rational arguments and skepticism. v. There is no one way to do science – therefore, there is no universal step-by-step scientific method. vi. New knowledge must be reported clearly and openly. vii. Scientists require accurate record-keeping, peer review and reproducibility. viii. Observations are theory laden. ix. Scientists are creative. x. Over the centuries, science builds in both an evolutionary and a revolutionary way. xi. Science is part of social and cultural traditions. x. Science and technology impact each other. xii. Scientific ideas are affected by the social and historical setting. xiii. Laws and theories serve different roles in science – therefore, students should note that theories do not become laws even with additional evidence.

Some researchers have refined this list to the following five tenets: i. Scientific knowledge is tentative (subject to change). ii. Science is empirically based (based on or derived from observation of the natural world). iii. Science is inferential, imaginative and creative. iv. Science is subjective and theory laden. v. Science is socially and culturally embedded.

There are two additional important aspects: i. The distinction between observation and inferences. ii. The relationships between scientific theories and data.

Nature and characteristics of science leads to important aspect that "Is science a process or science is product"?

Science Process and Product

National Science Teachers Association, Washington has advocated major items in the process of science. i. Science proceeds on the assumptions, based on centuries of experience, that the universe is not capricious. ii. Science knowledge is based on observation of samples of matter that are accessible to public investigation in contrast to purely private inspection. iii. Science proceeds in a piecemeal manner, even though it also aims at achieving a systematic and comprehensive understanding of various sectors or aspects of nature. iv.

Science is not and probably never will be a finished enterprise, and there remains very much more to be discovered how things in the universe behave and how they are interrelated. v. Measurement is an important feature of most branches of modern science because the formation as well as the establishment of laws are facilitated through the development of quantitative distinctions.

Scientific facts are tentative: Scientific facts are open to multiple interpretations. (the position in which a person is on a hill or a valley, in a moving train or from a window, or through a rare view mirror)[4].

Science and science processes begin with some kind of curiosity. Curiosity is based on some observations or some happening (natural or set in the immediate or extended environment).

Science has evolved to such an extent is all due to advancement in technology. Technology has given added extended limbs to science.

Science as Process

Process may involve things like steps to accomplish; way of doing work; planning various stages of an activity and establishing systematic steps for gathering and retaining information. In science, the ways of gathering information, thinking, measuring, solving a problem rather the ways of learning and knowing science are called processes of science[5].

“Processes of science” can be seen and studied in various ways. 1962-1968 Science A Process – Approach (SAPA) is a corresponding de-emphasis on specific science “content”. Of course, content is there – the children examine objects, liquids, gases, plants, animals, rocks and even moon photographs. But with some exceptions they are not asked to learn and remember particular facts or principles about these objects and phenomena. Rather they have to learn such things as how to observe solid objects and their motions, how to classify liquids, how to perform experiments.

Second meaning of process referred by Gagne (1966) (as cited in Rao 2008)[6] centers upon the idea that what is taught to children should resemble, what scientists do the processes. Scientists do observe, classify, measure and infer and make hypothesis and perform experiments. How they learn all these processes…. Over a period of time, by practicing them.

The third and perhaps most wider meaning of human intellectual development in the broad sense “ways of processing information” such processing grows more complex as one grows more complex as one grows from childhood…….onwards.

The psychological bases of science as a process approach.

Observing: beginning with identifying objects and properties of objects, this sequence proceeds to the identification of changes in various physical systems, the making of controlled observation and properties of objects, this sequence proceeds to the identification of changes in various physical systems, the making of controlled observation and the ordering of a series of observation.

Classifying: Development begins with simple classification of various physical and biological systems and progresses through multistage classifications their coding and tabulation.

Using numbers: This sequence begins with identifying sets and their numbers and progresses through ordering, counting, adding, multiplying, finding average, using decimals and powers of ten.

Measuring: It begins with the identification and ordering of lengths, development in this process with the demonstration of rules of measurement of length, area, volume, weight, temperature, force, speed and a number of derived measures applicable to specific physical and biological systems.

Using space- time relationships: This sequence begins with the identification of shapes, movement and direction. It continues with the learning of rules applicable to straight and curved paths, direction at an angle, changes in position and determination of linear and angular speeds.

Communicating: Development in this category begins with description of simple phenomena and proceeds through describing a variety of physical objects and systems and changes in them for observed result of experiments.

Predicting: For this process, the development sequence progress from interpolation and extrapolation of the data to the formulation of methods for using predictions.

Inferring: Initially, the idea is developed that inferences differ from observation. As development proceeds, inferences are constructed for observation of physical and biological phenomena and situations are constructed to test inferences drawn from hypothesis.

Defining operationally: beginning with the distinction between definitions which are operational and those which are not, this developmental sequence proceeds to the point where the child constructs operational definitions in problems that are new to him.

Formulating hypothesis: At the start of this sequence, the child distinguishes hypothesis from inferences, observations and predictions. Development is continued to the stage of constructing hypothesis and demonstrating tests of hypotheses.

Interpreting data: This sequence begins with descriptions of data and inferences based upon them, and progresses to constructing equations to represent data, relating data to statement of hypothesis and making generalizations supported by experimental findings.

Controlling variable: The development sequence for this integrated process begins with identification of manipulated and responding (independent and dependent) variable in a description of demonstration of an experiment. Development proceeds to the level at which the students being given a problem, inference, or hypothesis, actually conducts an experiment, identifying the variables and describing how variable are controlled.

Experimenting: This is the capstone of the “integrated” process. It is developed through a continuation of the sequence for controlling variables and includes interpretation of accounts of scientific experiments as well as the activities of stating problems, constructing hypothesis and carrying out experimental procedures.

Science as a product

Whatever information or ideas are acquire through various processes of science from the body of knowledge are referred as “Products” of science. Solution of every problem leads to the discovery of new problem and the cycle goes on and the result is accumulation of knowledge.

The basic components of knowledge are Facts, Concepts, Principles and Theories.

Facts: Are specific verifiable pieces of information obtained through observations and measurement. They are verifiable with reference to time and place.

Concepts: Concept are abstract ideas that are generalized from facts or specific relevant experiences. Concepts are single ideas represented by single word.

Every concept has five elements name, example, attributes, attribute value and rule.

Principles: are more complex ideas based on several complex concepts. They are the rules on which the activities or behavior of things depend.

Theory: broadly is related to principles that provide an explanation for phenomena are known as Theories or laws. These are used to explain, predict and relate various facts and phenomena. Theories confirmed by various scientific experimentations by scientists over a period of time becomes law.

Science is different from other subjects not just because it involves scientific method, but because it has processes that can be verified and can be replicated. Science has both process and products what happens in present scenario of science education in general and teaching science in specific is presented in the next section.

Present Scenario of Science Education in school

Science is a subject which cannot be taught in separation. As it has interrelated branches, has relation with life, environment and society as well. The present day traditional or conventional methods of teaching are dominated by memorization, dictation, and verbalism and give insufficient scope for practical and productive work.

These methods are devoid of correlating and integrating various subjects and experiences. The science courses should be so structured and taught so that the nature of science pervades curriculum. Science teaching should stress the different aspects, such as, science as a body of knowledge, as a method and as a way of thinking. But unfortunately the present education is more of teacher centered and rigid. The teaching learning process does not have any link with daily life of the students. It is more of mechanical and memorization of content and reproducing it in the examination. Science, which is more of a practical subject, is mostly being taught as theory based subject in the classrooms. It is quoted that in the prevailing system the content from the teacher’s note is being transferred to the students’ notes without any understanding, which really needs change in the prevailing system. Umashree[4] in her study revealed that lecture method was found in 70% of cases, lecture cum demonstration method in 10% and lecture cum activity teaching strategy only in 6% of the cases. Malhotra[5] also found that teachers often provide lectures and students mostly observe the teacher and their participation in classroom is very less[6].

Most of the teachers are of view that the courses of science subject are vast and so to finish the course in time, the lecture method is the better option. But the fact is that it does not provide the proper understanding of the subject to students. The theory and practical work are not properly co-related. If the theory portion is not properly clear to the students, then the basic objective behind the practical also is not clear to them. When teachers are not able to clear the theoretical concepts, the students are not aware about their practical implications. The proper grasp of the subject is not acquired and so students find the subject difficult. One of the objectives of teaching science at secondary level is to cultivate scientific temper, scientific attitude, social, moral, ethical and aesthetic values. But in present system there is lack in satisfactory attainment of this objective. Umashree[4] in her study found the reason for that is, the development of all these qualities is less feasible as specific guidelines how to achieve or develop these are not available to the teachers. She also stated the other reasons that science at secondary level is just one among other subjects and many students may discontinue with science.

Glynn, Yeany and Britton (cited in Winnie Wing Mui So)[7] stated that school science curricula are commonly placed on a continuum from "textbook-centered" to "teacher-centered" and that the textbook is the vehicle that drives the teaching. The textbook is usually accompanied by a large bulk of resource materials, such as additional information, overhead transparencies, wall charts, cassette tapes, teaching kits, worksheets, exercises, suggested activities and experiments, and the activity cards. Besides this, there are also "very useful" teachers' handbooks prepared by the publishers, which prescribe precisely how a concept should be taught (So, Tang & Ng, (cited in Winnie Wing Mui so)[7].

The problem of the heavy reliance on textbooks during science lessons was addressed in the American Association for the Advancement of Science Report[8], noting that the present science textbooks and methods of instruction emphasized the learning of answers more than the exploration of questions, memory at the expense of critical thoughts, bits and pieces of information instead of understanding in context, recitation over argument, reading in lieu of doing.

The present scenario is highly teacher centric and the science education is looked at a fixed, final and finished product. Rather, if we look at science we will have to focus on the very nature of science, which makes it tentative, dynamic and ever evolving.

Alternative conceptions and conceptual frameworks in science education

Learners' ideas in science have been variously labeled as alternative conceptions, alternative conceptual frameworks, preconceptions, scientific misconceptions, naive theories etc. Although some scholars have attempted to distinguish between these terms, there is no consensual usage and often these terms are in effect synonymous.

It has been found that some alternative conceptions are very common, although others appear quite idiosyncratic. Some seem to be readily overcome in teaching, but others have proved to be tenacious and to offer a challenge to effective instruction. Sometimes it is considered important to distinguish fully developed conceptions (i.e., explicit ways of understanding aspects of the natural work that are readily verbalized) from more 'primitive' features of cognition acting at a tacit level, such as the so-called phenomenology primitives.

The 'knowledge-in-pieces' perspective suggests the latter act as resources for new learning which have potential to support the development of either alternative or canonical knowledge according to how teachers proceed, whereas alternative conceptions (or misconceptions) tend to be seen as learning impediments to be overcome.

What research has shown is the prevalence among learners at all levels of alternative ways to thinking about just about all science topics, and a key feature of guidance to teachers is to elicit students' ideas as part of the teaching process. The success of constructivism is that this is now largely taken-for-granted in science teaching and has become part of standard teaching guidance in many contexts.

Previously there was a strong focus on the abstract nature of concepts to be learnt, but little awareness that often the teacher was not seeking to replace ignorance with knowledge, but rather to modify and develop learners existing thinking which was often at odds with the target knowledge set out in the curriculum.

Constructivism proposes new definitions for knowledge and truth that form a new paradigm, based on inter-subjectivity instead of the classical objectivity, and on viability instead of truth. Piagetian constructivism, however, believes in objectivity—constructs can be validated through experimentation. The constructivist point of view is pragmatic; as Vico said: "The norm of the truth is to have made it. "(as cited in Andreas Sofroniou)[9].

Meaning making process and construction of knowledge are the focus of constructivism. The objectivist and cognitivist views of learning science are discussed in the next subsection.

The nature of science its teaching learning process and constructivism can be better looked at from the purview of scientific paradigm discussed in the next subsection. How realism, objectivism and pragmatism of science can be juxtaposed with subjective reality where the interpretation and perceptions play a vital role?

Scientific Paradigm

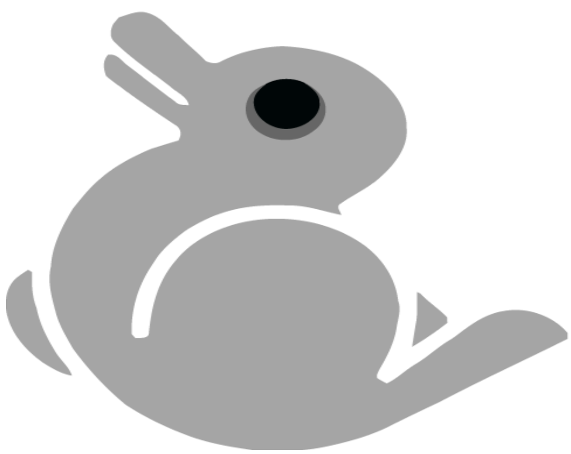
The Oxford English Dictionary defines the basic meaning of the term paradigm as "a typical example or pattern of something; a pattern or model". The historian of science Thomas Kuhn gave it its contemporary meaning when he adopted the word to refer to the set of practices that define a scientific discipline at any particular period of time. In his book The Structure of Scientific Revolutions Kuhn[10] defines a scientific paradigm as: "universally recognized scientific achievements that, for a time, provide model problems and solutions for a community of practitioners, i.e. i. What is to be observed and scrutinized, ii. The kind of questions that are supposed to be asked and probed for answers in relation to this subject, iii. How these questions are to be structured, iv. How the results of scientific investigations should be interpreted, v. How is an experiment to be conducted, and what equipment is available to conduct the experiment.

Table-1
Objectivist and cognitivist views of learning science

Objectivist view of learning Science	Constructivist view of learning Science
View about knowledge in Science	
Strict hypothetical, explains phenomena, in a fixed manner. There is fixed structure, also fixed way of dealing with it. Observation is based on theory based on sound reasoning.	Is tentative, amenable to change. Theory is made based on observation and its multiple interpretations.
Curricular Goals	
Science is given as a product It emphasizes on only explanation What we know about science is taught? Breadth of knowledge Basic scientific knowledge Curricular units discrete	Science is not a final product It keeps on evolving It emphasizes on growth and development of explanation. How and why we know of knowledge Depth of knowledge Contextualized science knowledge Curricular units connected
Role of Teacher	
Dissemination of knowledge given in textbook Non participant in knowledge construction Strictly adheres to curriculum. Provider of knowledge	Co-creator of knowledge Co-participant in knowledge construction Modify and adapt the given curriculum Teacher is one of the source of knowledge
Role of Learner	
Passive and talk only when asked to talk Scientific meaning is received	Scientific meaning is negotiated
Reflection	
Low level of reflection Reflection is linear	High level of reflection Reflections at all 5E levels Reflection in concentric circle
Classroom Setting	
It is linear It is teacher directed	It may be non linear Classroom is goal directed
Discipline	
Strictly enforced by the teacher to get focused attention of students	Discussion are open there is social negotiation Discipline is more flexible
Learning Experiences	
Are usually teacher centered at times, demonstration and lab work are used	Experiences are varied and usually in cooperative and collaborative mode. Experiences can be real, virtual, symbolic in the meaning making process
Assessment	
Usually paper pencil test, practical test and viva-voce or project work.	It can be varied as long as meaning making can be seen.

In “The Structure of Scientific Revolutions”, Kuhn[10] saw the sciences as going through alternating periods of normal science, when an existing model of reality dominates a protracted period of puzzle-solving, and revolution, when the model of reality itself undergoes sudden drastic change. Paradigms have two aspects. Firstly, within normal science, the term refers to the set of exemplary experiments that are likely to be copied or emulated. Secondly, underpinning this set of exemplars are shared preconceptions, made prior to – and conditioning – the collection of evidence. These preconceptions embody both hidden assumptions and elements that he describes as quasi-metaphysical; the interpretations of the paradigm may vary among individual scientists.

Kuhn[10] was at pains to point out that the rationale for the choice of exemplars is a specific way of viewing reality: that view and the status of "exemplar" are mutually reinforcing. For well-integrated members of a particular discipline, its paradigm is so convincing that it normally renders even the possibility of alternatives unconvincing and counter-intuitive. Such a paradigm is opaque, appearing to be a direct view of the bedrock of reality itself, and obscuring the possibility that there might be other, alternative imageries hidden behind it. The conviction that the current paradigm is reality tends to disqualify evidence that might undermine the paradigm itself; this in turn leads to a build-up of unreconciled anomalies. It is the latter that is responsible for the eventual revolutionary overthrow of the incumbent paradigm, and its replacement by a new one. Kuhn[10] used the expression paradigm shift (see below) for this process, and likened it to the perceptual change that occurs when our interpretation of an ambiguous image "flips over" from one state to another. (The rabbit-duck illusion is an example: it is not possible to see both the rabbit and the duck simultaneously). This is significant in relation to the issue of incommensurability.



Source: http://socrates.berkeley.edu
Figure-1
Rabbit Duck Illusion

A currently accepted paradigm would be the standard model of science. The scientific method would allow for orthodox scientific investigations into phenomena which might contradict or disprove the standard model; however grant funding would be proportionately more difficult to obtain for such experiments, depending on the degree of deviation from the accepted standard model theory which the experiment would be expected to test for. To illustrate the point, an experiment to test for the mass of neutrinos or the decay of protons (small departures from the model) would be more likely to receive money than experiments to look for the violation of the conservation of momentum, or ways to engineer reverse time travel.

Mechanisms similar to the original Kuhnian paradigm (as cited in Branjack)[11] have been invoked in various disciplines other than the philosophy of science. These include: the idea of major cultural themes, worldviews (and see below), ideologies and mindsets. They have somewhat similar meanings that apply to smaller and larger scale examples of disciplined thought. In addition, Michel Foucault (as cited in Thelemapedia)[12] used the terms episteme and discourse, mathesis and taxinomia, for aspects of a "paradigm" in Kuhn's original sense. In The Structure of Scientific Revolutions, Kuhn wrote that "Successive transition from one paradigm to another via revolution is the usual developmental pattern of mature science." Paradigm shifts tend to be most dramatic in sciences that appear to be stable and mature, as in physics at the end of the 19th century. At that time, a statement generally attributed to physicist Lord Kelvin (as cited in Paulo Maia)[13] famously claimed, "There is nothing new to be discovered in physics now. All that remains is more and more precise measurement." Five years later, Albert Einstein (as cited in Paulo Maia)[13] published his paper on special relativity, which challenged the very simple set of rules laid down by Newtonian mechanics, which had been used to describe force and motion for over two hundred years. In this case, the new paradigm reduces the old to a special case in the sense that Newtonian mechanics is still a good model for approximation for speeds that are slow compared to the speed of light. Philosophers and historians of science, including Kuhn himself, ultimately accepted a modified version of Kuhn's model, which synthesizes his original view with the gradualist model that preceded it. Kuhn's original model is now generally seen as too limited. Kuhn's idea was itself revolutionary in its time, as it caused a major change in the way that academics talk about science. Thus, it may be that it caused or was itself part of a "paradigm shift" in the history and sociology of science. However, Kuhn would not recognize such a paradigm shift. Being in the social sciences, people can still use earlier ideas to discuss the history of science.

Science education and learning are amenable to multiple interpretations and what make it different is the fluid nature and the processes involved in it. Kuhn’s paradigm (as cited in Attard)[14] helps to look at perceptions, interpretation and ambiguity. Various learning cycles can be designed and science can be designed and taught to the students.

Learning Cycles and Cognitive Psychology

The learning cycle is a generic term used to describe any model of scientific inquiry that encourages students to develop their own understanding of a scientific concept, explore and deepen that understanding and then apply the concept to new situations (Walbert) as cited in Orey M)[15]. The learning cycle is an established planning method in science education and is consistent with contemporary theories about how individuals learn (Lorsbach & Tobin as cited in Orey M)[15]. It is useful in creating opportunities to learn science. There are different models of the learning cycle, popular among these models are the three phase model, four phase model and the five phase model. Moyer, Hackett and Everett[16] stated that the learning cycle model of learning and teaching evolved for the past 40 years. The emergence of this model was influenced by the work of Jean Piaget and its application by Robert Karplus and Myron Atkin (1962)[17], who applied cognitive development theory and discovery learning to instructional strategies in elementary science. Karplus and Myron Atkin with the support of the National Science Foundation developed a three phase learning cycle that served as the central teaching/learning strategy in the newly introduced Science Curriculum Improvement Study (SCIS) program (Atkin & Karplus, 1962)[17]. The first three phase model of the learning cycle consisted of: Exploration, Invention and Discovery and were first used in the SCIS program (Moyer et al,[15]; Trowbridge et al, 2000 as cited in Atilla)[18]. Continuing, they noted that these terms were modified to Exploration, Concept Introduction and Concept Application by Karplus. Moyer et al[16] reported the observation of Barman and Kotar[19] and Hackett and Moyer[20] that the cycle evolved through modification to include additional …….phases such as engage, explore, explain, elaborate, extend and apply and are used to frame single guided discovery lesson as well as extend experiences such as chapters and units. They noted that a fifth phase, evaluate, was incorporated into an elementary science program developed by the Biological Science Curriculum Study (Biological Science Curriculum Study[21]. These series of modifications gave birth to the model called 5E learning cycle. The 5E cycle has even been further modified to show different forms and versions. However, the model specifically adopted for this study is the Bybee's[22] 5E model which has five stages. The five stages include: Engagement, Exploration, Explanation, Elaboration and Evaluation. At all the stages, evaluation is done by the teacher to determine the level of learning.

The two theories under cognitivism are Piaget's theory of cognitive functioning development and Vygotsky's theory of learning. The basic principle of philosophic realism is that matter is the ultimate reality. The realists are of the view that the world we perceive is not a world that we have recreated mentally but the world as it is (Kneller, cited in William ware[23]. This epistemological stance suggests that the selection of the learning task for the student should be the responsibility of the school. The initiative in education, therefore, lies with the teacher, not the student, who must decide what subject matter can be made to satisfy the student personal needs and interest[23]. Kneller further stated that to instruct the student in the knowledge that matters most is the true end of education; satisfying the interest is only a means to this end, a useful teaching strategy. This specification and stand is clearly demonstrated in the lecture method of instruction. The major principle in Piaget's Constructivist Theory of Cognitive Functioning is that learning is attained through 'construction[24]. This theory suggests that human knowledge is innate and that human knowledge is directly shaped by experience. This theory sees learning as occurring based on the interaction between what the learner already knows and the physical environment. King (1998 as cited in Ajaja 2013)[25], while discussing Piaget's theory, noted that human beings are capable of extending biological programming to construct cognitive systems that interpret experiences with objects and other persons. This thought provides a model for building classroom instruction for small groups and individuals that will lead to practice and learning in the classroom. King as cited in Ajaja[25] argued that peer or small group interactions provide rich and necessary context for students to revise their current cognitive system which may lead to invention. The basic principle of this theory, which is creating knowledge through interaction between the learner and the environment perfectly, agrees with the fundamental structures of concept mapping, cooperative learning and 5E learning cycle. They all emphasize active participation in lesson through physical activities and mental engagement.

Vygotsky's Theory of Learning sees learning as appropriation which resides within the learner. Vygotsky[26] believed that a student's learning development is facilitated by social interaction with more sophisticated individuals who provide guidance during the learning process. The theory of zone of proximal development[26] emphasize that children learn best if placed in an environment which requires thinking slightly above their developmental level. Vygotsky believed that learning development in such environment is facilitated by the social interaction among peers and between teachers and learners. Moyer et al[16] stated that from the work of Vygotsky, "it can be seen that the value of students working in small groups to conduct science investigations comes from the discourse that takes place". This reasonably follows that the skillful intervention of a teacher can elevate the level of students' thinking and learning. The structure of this theory also agrees with the principle of concept mapping, cooperative learning and 5E learning cycle in part, particularly in the area of skillful intervention of the science teacher to elevate students' thinking and learning, but more with the cooperative learning and 5E learning cycle because of the existence of social interaction among students in these two models to bring about learning.

Most empirical studies on the effectiveness of learning cycle when used as an instructional strategy found significant improvement in students' achievement, retention, attitude and correction of misconceptions. Studies by Baser[27], Pulat[28], Lee[29], Lord[30], Nuhoglu and Yalcin[31], and Whilder and Shuttleworth[32] found that students' achievement improved after the instruction of 5E learning cycle. Specifically, the empirical study by Lee[29] found out that the students acquired knowledge about plants in daily life easier and understood the concepts better when taught with learning cycle. Pulat[28] in another study determined the impact of 5E learning cycle on sixth grade students' Mathematics achievement and attitude towards the subject. The results showed that the students' mathematics achievement improved after the instruction of learning cycle. Studies by Ajaja[33] and Nuhoglu and Yalcin[31] showed that learning cycle enhanced the retention of science knowledge. Nuhoglu and Yalcin[31] specifically emphasized that learning cycle makes knowledge long lasting and that students become more capable of applying their knowledge in other areas outside the original context.

Conclusion

Science by nature is dynamic the last few decades have seen lot of growth in scientific development. By nature students are also curious and despise authoritarian functioning of the adult society. The authors have focused on definition of science, which by definition is also a growing and evolving entity. It grows with new researches and the ways of approaching them makes all the difference. Nature and characteristics of science are discussed to explain how by nature itself science is amenable to multiple interpretations. Scientific processes and products are discussed and also why processes and the ways of conducting processes influence the product shows a subjective cognitivist realm. Current scenario of science education and science teaching is represented as found by researchers. Scientific paradigm by Kuhn[10] is discussed to show how interpretation is affected by the illusion created by the duck rabbit illusion. Cognitivist theory by Piaget[24] and Vygotsky[26] are discussed and the researches done based on cognitivist psychology and learning of science to show how cognitivist approach affects the learning of science among students. Difference between the behaviourist and cognitivist learning has been discussed to show how multiple interpretations and cognitive, collaborative skills aid in learning science. Learning cycles and cognitivism has been discussed along with the evolution of various learning cycles. It also shows effectiveness of the learning cycle.

Source: http://mathworld.wolfram.com
Figure-2
Different Perception young girl old lady illusion

To conclude we can say no two eyes see the same picture in similar manner. One may see a duck in the same picture other person may see a rabbit (Figure-1). One may see old lady in the same picture other may not see an old lady (Figure-2). As the perception changes so the conclusion also changes. But in a collaborative setting both aspects can be discussed and acknowledged through social negotiation at the cognitive level. Thus, Science education, science teaching learning process and cognitive psychology can together help in designing instructional design that can help the students to understand the subject of science in a better manner.

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