CHAPTER - I

CONCEPTUAL FRAMEWORK — Theoretical framework

1.0 Introduction

According to Mc. Combs (2000) constructivism focuses on the learner and each learner's perceptions, need and motivation. There is a balanced focus on the individual learner, the learning process and the learning context. Basic idea of constructivism is that the learner must construct knowledge. The teacher cannot supply it. It is an approach in which the learner is building an internal illustration of knowledge, a personal interpretation of experience. It is active, constructive, cumulative, goal directed, diagnostic and reflective (Simons 1993). Constructivism emphasizes the careful study of the processes by which children create and develop their ideas. Teachers might help make this connection by asking reflective questions such as the following:

- How does this idea fit with what you already know?
- In what way is this problem like other problems / situations you are experienced?
- What is about this problem that reminds you of Yesterday's problem? (Cook and Rasmussen, 1991.)
The networks or “Cognitive schemas” that exist in the learner’s mind are the principal determining factors for how an idea will be constructed.

These networks are the products of both constructing knowledge and developing concepts. Constructivism concentrates on learning how to think and understand. It initiates student directed learning. Students are able to clearly cognisize the principles they have learnt and carry the new knowledge to real life. It also provides realistic learning activities that initiate curiosity and prompt students to formulate their own questions.

**What is constructivism?**

Constructivism is basically a theory based on observation and scientific study about how people learn. It says that people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences. In the classroom, the constructivist view of learning can point towards a number of different teaching practices. In the most general sense, it usually means encouraging students to use active techniques to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing. Constructivism does not dismiss the active role of the teacher or the value of expert knowledge. Constructivism modifies that role, so that teacher help students to construct knowledge rather than to reproduce a series of facts. The constructivist teacher provides tools such as problem solving and inquiry based learning activities with which students formulate and test their ideas, draw conclusions and inferences and pool and convey their knowledge in a collaborative learning environment. Constructivism
transforms the student from a passive recipient of information to an active participant in the learning process. Always guided by the teacher, students construct their knowledge actively rather than just mechanically acquiring knowledge from the teacher or the text book. Student become engaged by applying their existing knowledge and real world experience, learning to hypothesize, testing their theories and ultimately drawing conclusions.

**History of constructivism**

The concept of constructivism has roots in classical antiquity, going back to Socrates dialogues with his followers, in which he asked directed questions that led his students to realize for themselves the weaknesses in their thinking. The Socratic dialogue is still an important tool in the way constructivist educators assess their students learning and plan new learning experiences. Jean Piaget and John Dewey developed theories of childhood development and education, what we now call progressive education that led to the evolution of constructivism. Piaget believed that humans learn through the construction of one logical structure after another. He also concluded that the logic of children and their modes of thinking are initially entirely different from those of adults. The implications of this theory and how he applied them have shaped the foundation for constructivist education. Dewey called for education to be grounded in real experience. Inquiry is a key part of constructivist learning. Among the educators, philosophers, psychologists and sociologists who have added new perspectives to constructivist learning theory and practice are Lev Vygotsky Jerome Bruner and Dravid Ausubel. Vygotsky introduce the social aspect of learning into constructivism. He defined the "Zone of proximal
development”, according to which students solve problems beyond their actual developmental level (but within their level of potential development) under adult guidance or in collaboration with more capable peers. Bruner initiated curriculum change based on the notion that learning is an active, social process in which students constructs new ideas or concepts based on their current knowledge. Ausubel introduced the concept of meaningful learning, which constitutes an important part of constructivist learning. Modern educators who have studied, written about and practiced constructivist approaches to education include John D. Bransford, Ernst Von Glaserfeld, Eleanor Duckworth, George Forman, Roger Schank, Jacqueline Grennon Brooks and Martin. G. Brooks.

Although constructivist theory has reached high popularity in recent years, the idea of constructivism is not new. Aspects of the constructivist theory can be found among the works of Socrates, Plato and Aristotle all of which speak of the formation of knowledge. Saint Augustine taught that in the search for truth, people must depend up on sensory experience. This of course left him out of balance. More recent philosophers such as John Locke (17th to 18th centuries) taught that no man’s knowledge can go beyond his experience. Kant (late 18th centuries) explained that the “Logical analysis of actions and objects lead to the growth of knowledge and the view that one’s individual experiences generate new knowledge” (Brooks and Brooks, 1993). Although the main philosophy of constructivism is generally credited to Jean Piaget.
Pestalozzi maintained that the educational process should be based on the natural development of the child and his or her sensory influences. Pestalozzi’s basic pedagogical innovation was his insistence that children learn through the senses rather than with words. He labeled rote learning as mindless, and he emphasized instead linking the curriculum to children’s experiences in their homes and family lives. (Ornstein and Hunkins, 1993 P-75). However, Piaget is regarded as the father of constructivism and provided the foundation for modern day constructivism. In Piaget’s view, intelligence consists of two interrelated processes, organization and adaption. People organize their thoughts so that they make sense, separating the more important thoughts from the less important ones as well as connecting one idea to another. At the same time, people adapt their thinking to include new ideas, as new experiences provide additional information. This adaptation occurs in two ways, through assimilation and atomization. In the former process, new information is simply added to the cognitive organization already there. In the latter, the intellectual organization has to change some what to adjust to the new idea. (Berger, 1978).

Constructivist theory in education actually is a branch of Neo-Piagetian thought which is rooted in Personal constructivism (Novak, 1977; Von Glasersfelt, 1989). Soloman (1987), Millar (1989), and Coburn (1993) have taken Personal constructivism and have paved a way for contextual constructivism. Contextual constructivism is defined by how the learner interprets phenomena and internalizes these interpretations in terms of their previous experience and culture. Coburn (1991) explains one must not suppose that cultural identification is limited to such conspicuous group identifiers as race, language or ethnicity each of these no more identifies a
homogeneous cultural group. In addition to race and language, other significant factors influence the construction of meaning and therefore are part of cultural identity. These include economic and education levels, occupation, geographic location, gender religion and philosophy. Thus, one can expect to find considerable variation among students. A student constructs knowledge so that the knowledge is meaningful in the student’s life situation (Coburn, 1991).

Constructivism or a constructivist view puts the students, their interests, and previous experiences and knowledge as paramount parts of understanding in designing curriculum. This has a particular impact when exploring the implications of pedagogy and teacher training.

**Constructivism – significant contributors and fundamental principles**

Constructivism refers to a philosophy of teaching and learning. Many of the concepts underlying the constructivist approach to education have a long history. Several concepts have been reflected in the work of Dewey, Vygotsky, Piaget, Bruner and other educational researchers.

Learning, according to the constructivists, is a process whereby new meaning are created by the learner context of his/her current knowledge. Despite variations among the constructivism – based approaches principles are common to all of them. Constructivists view children as inherently active, self-regulating and construct knowledge in developmentally appropriate ways within their social context. Constructivist believe that only
full participation of their own learning will lead to deep, real and rich understanding and use of knowledge which in turn will increase ability to apply what is learned (Harris and Graham, 1994).

As new experiences and information are encountered, the learner's existing structure of knowledge and experience interact and transformations cause knowledge and learning to be personalized. An important constructivist idea is that the whole must be fully grasped before the parts can be mastered, of knowledge as described by Poplin (1988) involves a first phase which involves plenty of independence amid firsthand experience. Constructivism perceives errors as being essential to learning. Perception of error leads to disequilibria. This disequilibrium is the impetus for further learning.

**Constructivism – Its Theory and Models**

Constructivism is anchored on cognitive psychology but from a practical perspective has roots in the "progressive" model of John Dewey (1933). According to this theory, learners are active participants in knowledge acquisition and engage in restructuring, manipulating, reinventing, and experimenting with knowledge to make it meaningful, organized and permanent. Learning is an internal process influenced by the learner's personality, prior knowledge and learning goals (Davidson, 1995).

Constructivism describes a learner-centered environment where knowledge and the making of knowledge is interactive, inductive and collaborative, where multiple perspectives are represented, and where questions are valued (Brooks and Brooks, 1993; Brown, Collins and Duguid,
1989; Lebow, 1993) and the importance of context related to knowledge and learning is emphasized. That is knowing and the process of learning are affected by the context of the learning environment and are referred to as "situated cognition" (Brown, Collins and Duguid, 1989). In addition, within the constructivist environment the importance of "authentic activity" (Brown, et al., Lebow, 1993) is emphasized as a part of the learning process.

Lerman (1989) following Kilpatrick (1987) suggested that the core epistemological theses of constructivism are

'Knowledge is actively constructed by the cognizing subject, not passively received from the environment'. 'Coming to know is an adaptive process that organizes one's experiential world; it does not discover an independent, pre-existing world outside the mind of the knower'.

First point is a psychological claim and second the epistemological claim. Wheatley (1991) offers a nearly identical summation of the epistemological core of constructivism. He said

"The theory of constructivism rests on the two main principles . . . . Principle one states that knowledge is not passively received, but is actively built up by the cognizing subject . . . . Principle two states that the function of cognition is adaptive and serves the organization of the experiential world not the discovery of ontological reality . . . . Thus we do not find truth but construct viable explanations of our experiences."

Scott (1987) defines a constructivist in science as one who "perceives students as active learners who come to science lessons already holding
ideas about natural phenomena, which they use, make sense of everyday experiences . . . . Such a process is one in which learners actively make sense of the world by constructing meaning”.

For Piaget, action rather than language is the basis of all knowledge. His theory describes the gradual evolution of thought in logical terms from stage to stage, which are also hierarchically determined. Vygotsky goes a step further saying “Instruction precedes development”. He, therefore, analyzed intellectual development as a function of instruction . . . . Concepts do not exist in isolation. Vygotsky had a firm belief i.e. belief in the social construction of the mind. Within the context of cultural development, any function in the child appears twice, namely social plane and psychological plane. The language plays the mediating role and Vygotsky thus, talked of the tools of language. He had a bold conception in the “Zone of proximal development” whereby individual activity is detached from communal practice. Jerome Bruner (1966) unlike Piaget believed in symbolic growth. He informed about what ought to be the plan of attack unlike Piaget who talked of the universal child. Bruner stressed the role of language and culture in education of children so that the children learn “how to learn”. Along with Piaget and Bruner, Ausubel (1978) was also a strong advocate of meaningful learner. He saw the importance of meaning as a key factor learning.

From the above theories, constructivist have evolved the following models and approaches.

There are several constructivist models and approaches.
• The learning cycle is a three-step design that can be used as a general framework for many kinds of constructivist activities. The process begins with the "discovery" phase. In it, the teacher encourages students to generate questions and hypotheses from working with various materials. Next, the teacher provides "concept introduction" lessons. Here, the teacher focuses on the students' questions and helps them create hypotheses and design experiments. In the third step, "concept application" students work on new problems that reconsider the concepts studied in the first two steps. The cycle continues again.

• The Biological Science Curriculum Study (BSCS) developed an instructional model for constructivism which was called the "Five ES" by Roger Bybee. In these models the process is explained by employing five "E"s. They are: Engage, Explore, Explain, Elaborate and Evaluate.

• Gagnon and Collay developed another constructivist learning design. In this model, teachers implement number of steps in their teaching structure. They develop a situation for students to explain; select a process for groupings of materials and students; build a bridge between what students already know and what teachers want them to learn; anticipate questions to ask and answer without giving away an explanation; encourage students to exhibit a record of their thinking by sharing it with others and solicit students' reflections about their learning.
Mc. Clintock and Black (1995) derived a model from several computer technology-supported learning environments. The Information Construction (ICON) model contains seven stages:

A. **Observation:** Students make observations of primary source materials embedded in their natural context or simulations thereof.

B. **Interpretation Constructions:** Students interpret their observations and explain their reasoning.

C. **Contextualization:** Students construct context for their explanations.

D. **Cognitive Apprenticeship:** Teachers help student apprentices' master observation, interpretation and contextualization.

E. **Collaboration:** Students collaborate in observation, interpretation and contextualization.

F. **Multiple Interpretations:** Students gain cognitive flexibility by being exposed to multiple interpretations from other students and from expert examples.

G. **Multiple Manifestations:** Students gain transferability by seeing multiple manifestations of the same interpretations.

**Planning and Learning Cycle. 4E’s Model**

The four E’s indicate exploration, explanation, expansion and evaluation. In the first stage, *Explore*, the students first encounter and identify the instructional task. Here, they make connections between past and present learning experiences. Lay the organizational ground work for the activities ahead and stimulate their involvement in the anticipation of these activities. The students have the opportunity to get directly involved with phenomena and materials. Involving themselves in the activities along
with others, students build a base of common experience, which assist them in the process of sharing and communicating. The student observes, identifies, classifies in this phase.

In the second stage, **Explain**, is the point at which the learner begins to put the abstract experience through which he or she has gone into a communicable form. Communication occurs between peers, the facilitator or within the learner himself.

In the stage three, **Expand**, the students expand on the concepts they have learned, make connections to other related concepts and apply their understandings to the world around them.

And lastly, **Evaluate**, the fourth “E”, is an ongoing diagnostic process that allows the teacher to determine if the learner has attained understanding of the concepts and knowledge. Evaluation and assessment can occur at all points along the continuum of the instructional process.

This model is simple, thorough, convenient and conducive to use in the classroom and has considerable potential to have an effect on the improvement in students’ learning. It is not only a planning model but also a teaching model. This Constructivist model closely follows the original format of the Science Curriculum Improvement Study (SCIS), which is credited with the greatest student achievement gains in major research studies and significant improvements in student science and their attitudes and inquiry skills when compared to similar experimental science programs and traditional science curricula (Shymansky et al. 1982; Bredderman, 1982).
Classification system for the various constructivist paradigms

Endogenous constructivism is exemplified by Piagetian theory and emphasizes the internal knowledge. While the environment may induce disequilibria and the opportunities for constructivist knowledge, it is the meta cognitive reflection that occurs within the child that leads to construction of new thoughts. Endogenous constructivist promote child determined exploration, guided discovery asking interesting questions immersion in meaningful activities, testing of predictions etc., as compared to direct instruction.

Exogenous constructivism views the child as an active learner in reciprocal interaction. Observed behaviour explicitly presented information, and other environmental factors influence construction. Teaching, modeling, discussion and explanation are all part of instruction. The child does merely copy externally presented material, but rather adapts this input and seeks to fit this to what he knows, thus constructing new knowledge.

Dialectical constructivism is exemplified by Vygotskian theory and seeks to encompass aspects of both approaches. The source of knowledge is seen as lying in continuing interactions between the child and the environment. Development is seen as the result of interactions at biological, psychological, sociological and physiological. Scaffolded instruction, teacher – guided discovery, co-operative learning and teacher modeling are valued methods in this approach.
An overview to constructivist model of learning

Vygotsky while speaking on teaching and the role of teachers discusses the concept of ‘constructivism’ as a means for the experiences building and knowledge development by learners themselves. In teaching of science, the teacher must act as a ‘scaffolder’ to build understanding in students from what actually students know or experience from the immediate environment. The new knowledge developed must be ‘construct’ of the learner himself using his previous knowledge and the context of learning in which they learn things. The child must be encouraged to interact with science knowledge, provided through the learning environment created by teachers, books, labs, fields, workplaces and other media. The existing fund of knowledge of the learner supports the construction of new meanings. As the ‘proximal zone’ develops the meaning continually changes, which results in a new understanding and development of advanced constructs. Thus constructivism is that process of building knowledge, attitude, values and skills by the learner himself by making sense of their environment through constructing personal explanations of phenomena. Berger, Luckmanns and shutz (1967) argues that, as individuals and groups see each phenomena differently, there exist ‘multiple realities’ and hence each ‘construct’ by individual science learner has its own significance in knowledge development. Moreover, the individual ‘constructs’ seem to work well in their daily life situations so that the students can bridge the gap of their existing knowledge and newly acquired knowledge. In this constructivist model of learning, an interesting/important fact is that the position of prescribed reading materials, ready made finite piece of knowledge suggested by the elder generation and a planning of lessons with
prefixing of objectives on the basis of visualizing a learner from the perspective of an adult teacher etc., will be in question.

The constructivist model of learning assumes that learning never takes place in isolation. The learning environment or context (both in and outside the classroom) has a dynamic interplay between human components in classroom—teacher and learners—and the task—science knowledge. So in the constructivist model of learning four elements. Teacher, learners, tasks and context(s) interact among themselves.

**Figure: 1.1 Constructivist model of Learning**

The interaction of various elements of the constructivist model of learning is illustrated diagrammatically in the above figure. It is to be noted that a change in any part of the model will influence other parts. (The Piagetian thoughts of individual constructivism with special emphasis of
advancements in age of the individual learner take a new dimension of social constructivism in Vygotskian thoughts).

The Vygotskian theoretical contribution to the constructivist model acknowledges a metacognitive dimension of knowledge achievement through science learning. In a constructive environment, by using the 'constructs' the science learners "would be able to achieve a fairly clear understanding of his or her own knowledge acquisition process and to exert deliberate control - the very essence of metacognitive process over them" (Ivan 1997). The possibility of conceptualizing science and scientific knowledge through a metacognitive process by constructing learners own knowledge from pre-existing knowledge, natural or created environment helps them to execute an intra psychic control of the own inner processes.

An interesting fact is that in a 'constructivist' environment of learning, the learners will behave as scientists – observing their natural and artificial environment, creatively developing generalisations and verifying in the light of their observations. (Recall Armstrongian Heurism). As "science is a major area of human mental and practical activity which, generate knowledge" (Gorden and Keith, 2000) the constructivist model of learning can result in the development of process skills" by the learners. The model demands from the science teachers to respect and encourage the natural way of developing learners own knowledge even though that may be illogical to and unacceptable as per the teachers knowledge and criteria.

A doctoral study by Hogen et al (2000) on "students knowledge about the natural sciences developed through constructivist approach of information processing," identifies two categories of knowledge – Distal and
proximal — the former on the students declarative knowledge of science while the latter is concerned with the personal understanding, beliefs and commitments of their own science learning and the scientific knowledge they encounter. Thus the process of assimilation and accommodation during the schema — building (Piaget, 1952) act of the learners will be assisted positively by constructivism. This is a point where the ‘individual constructivism’ (Piaget) and social constructivism (Vygotsky) naturally coincides.

Constructivism and its impact on best practices:

Von Glassersfeld (1990) said, “Knowledge is not a commodity which can be communicated”. The philosophy of constructivism has been discussed and debated by researchers such as Von Glassersfeld, Tobin, Cobb, Coburn but these authors are concerned about constructivism as a philosophy and through debate leave the practitioner in the field confused. Other authors have explored the impact of constructivism on pedagogy and even have prescribed certain “best practices” that a “constructivist” teacher should exhibit, only to find themselves under careful secreting and condemnation of the philosophical folk which state that a philosophy has no prescribed methods. Specifically, Tobin and Tippins (1993) warn against reducing constructivism to set of methods and that this would “diminish its power as a set of intellectual referents for making decisions in relation of actions”.
In 1991 Wheatley proposed a model of constructivist teaching using the problem centered learning approach, stating that “each student must be encouraged to build his/her own conceptual constructs that will permit the ordering of knowledge into useful problem solving schema”. Then Wheatly proposed that the teachers role is to “provide stimulating and motivational experiences through negotiation and act as a guide in the building of personalized schema.

Wheatley’s (1991) problem centred learning approach has 3 components: tasks, groups and sharing. These practices are common with constructivist classroom. Brooks and Books (1993) have 5 guiding principles of constructivism. The first using the problems of relevance to students in instruction. The second being the learning is structured around primary concepts. The third valuing students point of view. The fourth is in adapting curriculum to address students suppositions. And the fifth is assessing students learning in the context of teaching.

**Faces of Constructivism**

The various faces of constructivism are as follows:

(i) **Trivial Constructivism**

This is the simplest idea in constructivism what Glaserfeld (1990) calls trivial constructivism also known as personal constructivism. The principle has been credited to Piaget, pioneer of constructivist thought and can be summed up by the following statement:

“Knowledge is, actively constructed by the learner, not passively received from the environment”. This reacts against other epistemologies
promoting simplistic model of communication as simple transmission of meanings from one person to another. The prior knowledge of the learner is essential to be able to "actively" construct new knowledge.

(ii) Radical Constructivism

It adds a second principle to trivial constructivism, which can be expressed as: "Coming to know is a process of dynamic adaptation towards viable interpretations of experience. The knower does not necessarily construct knowledge of a "real" "world".

Radical constructivism challenges the notion of external reality; no amount of stimuli, experience, or thinking is sufficient to prove the existence of an external agent. Radical constructivism does not deny an objective reality but simply states that we have no way of knowing what that reality might be. Mental constructs, constructed from past experience. However, when they fail to work because of external or internal constraints, thus causing problem, the constructs change to try and accommodate the new experience. Within the constraints that limit our construction, there is room for infinity of alternatives. From a radical constructivist perspective, communication need not involve identically shared meanings between participants. It is sufficient for their meanings to be compatible (Hardy and Taylor, 1997). The emphasis here is still clearly on the individual learner as a constructor. Neither trivial nor radical constructivism looks closely at the extent to which the human environment affects learning. These issues are focused on in more detail by social, cultural and critical constructivism.
(iii) Social Constructivism

The social world of a learner includes the people that directly affect that person—teachers, friends, students, administrators and participants in all forms of activity. This takes into account the social nature of both the local processes in collaborative learning and in the discussion of wider social collaboration in a given subject, such as science.

Vygotsky (1978), a pioneering theorist in psychology focused on the roles that society play in the development of an individual. He believed everything is learned on two levels—first, through interaction with others and then integrated into the individual’s mental structure. A more experienced partner is able to provide “scaffolding” of the subject matter to support the student’s evolving understanding. Another aspect of Vygotsky’s theory is the idea that the potential for cognitive development is limited to a “Zone of proximal development”. This zone is the area of exploration for which the student is cognitively prepared but requires help and social interaction to fully develop. Cobb (1994) followed by Salomon and Perkins (1998) suggested that “acquisition” and “participation” the two metaphors of learning interrelate and interact in synergistic ways.

Teaching strategies using social constructivism as a referent include teaching in contexts that might be personally meaningful to students, negotiating taken-as-shared, meanings with students, class discussions, small-group collaboration, and valuing meaningful activity over correct answers (Wood et al., 1995).
(iv) Cultural Constructivism

Beyond the immediate social environment of a learning situation are the wider context of cultural influences including custom, religion, biology, tools and language. For example, the format of books can affect learning, by promoting views about the organization, accessibility and status of the information they contain.

“What we need is a new conception of the mind, not as an individual information processor, but as a biological, developing systems that exists equally well within an individual brain and in the tools, artifacts, and symbolic systems used to facilitate social and cultural interaction” (Vosniadou, 1996).

The tools that we use, affect the way we think (by tools including language and other symbolic systems as well as physical tools). Salomon and Perkins (1998) identified two effects of tools on the learning mind. Firstly, they redistribute the cognitive load between people and the tool while being used and secondly, the use of tool can affect the mind beyond actual use, by changing skills, perspectives and ways of representing the world. For example, Computers carry an entire philosophy of knowledge construction, symbol manipulation, design and exploration, which if used in schools can subversively promote changes in curricula, assessment, and others changes in teaching and learning.

Higher mental functions are, by definition, culturally mediated. They involve not a direct action on the world but an indirect one; that takes a bit of material matter used previously and incorporates it as an aspect of action. So far as that matter itself has been shaped by prior human practice, current action incorporated the mental work that produced in the particular form of that matter (Cole and Wertsch, 1996).
Critical Constructivism

Critical constructivism looks at constructivism within a social and cultural environment, but adds a critical dimension aimed at reforming these environment in order to improve the success of constructivism applied as referent.

Taylor (1996) describes critical constructivism as a social epistemology that addresses the socio-cultural context of knowledge construction and serves as a referent for cultural reform. Critical constructivism adds a greater emphasis on actions for change of learning teacher. It is a framework using the critical theory of Habermas to help make potentially disempowering cultural myths more visible and hence more open to questions through conversation and critical self-reflection. An important part of that framework is the promotion of communicative ethics that is conditions for establishing dialogues oriented towards achieving mutual understanding (Taylor, 1998). The conditions include: a primary concern for maintaining empathetic, caring and trusting relationships; a commitment to dialogue that aims to achieve reciprocal understanding of goals, interests and standards; and concern for and critical awareness of the often-invisible rules of the classroom, including social and cultural myths. Together these myths produce a culture that portrays classroom teaching and learning as "a journey through a pre-constructed landscape". Modification of such entrenched environments to reduce myths and promote approaches based on constructivism is problematic; because of the self-reinforcing mature of administration and the effects of wider culture.
(vi) Psychological Constructivism

Psychological constructivism is based on Jean Piaget's model of development of the individual. The process focuses learning as a personal, individual, intellectual construction based on experiences of one in the world. To Piaget, the child's mind is self-organized by a constant antagonism between internal, subjective mental states and external reality. In Piagetian theory, there is no objective ontological reality. For Piaget (1952, 1969) the development of human intellect proceeds through adaptation and organization. Adaptation is a process of assimilation and accommodation, where, on one hand, external events are assimilated into thoughts and on the other, new and unusual mental structures are accommodated into the mental environment. The process of organization refers to the structuring of the adapted mental material. Piaget considers that the organization of the mind is accomplished through a series of increasingly complex and integrated ways, of which the simplest one is scheme, i.e. a mental representation of some action that can be performed on an object. As Piaget identifies knowledge with action, he considers that mental development organizes these schemes in more complex and integrated ways to produce the adult mind. This progression occurs because of the reciprocal effects of assimilation and accommodation constantly forced to attain equilibrium between subjective and objective states.
Fig. 1.2: Construction of Knowledge.

Source: Adapted from Appleton. (1993) “Using theory to guide Practice: Teaching science from a constructivist perspective”
Learning by doing and forming ideas from exploration is the underlying theory behind psychological constructivism. The child is viewed like a scientist who possesses insights, questions, problem solving strategies and new ideas that will be used in experimentation. The scientific process of puzzling, probing, testing are incorporated into the approach. The child develops his picture or understanding of the physical world through manipulation and seeing relationships between objects and learning centrally determined names and labels for the ideas, items and activities involved through experience. Key to the theory is fostering independence in the child, not dependence on adults so that, activities, curriculum, environment are based on risk-taking, self-direction, guided or totally free discovery type, experimentation through social interaction and problem solving. The teacher acts as a facilitator of the educational context. The teacher provides opportunities for observation, interaction of students with each other and with the teacher through questioning techniques, modifying the environment, supporting during conflicts and planning and creating curriculum.

**Some Critical Perspectives of Constructivism:**

Constructivism has been criticized on various grounds. Some of the charges that critics level against it are: It's elitist. Critics say that constructivism and other progressive educational theories have been most successful with children from privileged backgrounds who are fortunate in having outstanding teacher, committed parents and rich home environments. They argue that disadvantaged children, lacking such resources, benefit more from more explicit instruction. Social constructivism leads to collaboration critics say the collaborative aspects of
Constructivist classrooms lead to a "tyranny of the majority", in which a few students' voices or interpretations dominate the group's conclusions and dissenting students are forced to conform to the emerging consensus. There is little hard evidence that constructivist methods work. Critics say that constructivists by rejecting evaluation through testing and other external criteria, have made themselves unaccountable for their students' program.

**Benefits of constructivism**

- Children learn more and enjoy learning more when they are actively involved, rather than passive listeners.
- Education works best when it concentrates on thinking and understanding, rather than on rote memorization. Constructivism concentrates on learning how to think and understand.
- Constructivist learning is transferable. In constructivist classrooms, students create organizing principles that they can take with them to other learning settings.
- Constructivism gives students ownership of what they learn, since learning is based on students questions and explorations engaging the creative instincts develops students' abilities to express knowledge through a variety of ways. The students are also more likely to retain and transfer the new knowledge to real life.
- By grounding learning activities in an authentic real-world context, constructivism stimulates and engages students. Students in constructivist classrooms learn to question things and to apply their natural curiosity to the world.
• Constructivism promotes social and communication skills by creating a classroom environment that emphasizes collaboration and exchange of ideas. Students must learn how to articulate their ideas clearly as well as to collaborate on tasks effectively by sharing in group projects. Students, therefore, exchange ideas and learn to negotiate with others and to evaluate their contributions in a socially acceptable manner. This is essential to success in the real world, since they will always be exposed to a variety of experiences in which they will have to co-operate and navigate among the ideas of others.

Constructivism concentrates on learning how to think and understand. Children learn more and enjoy learning more when they are actively involved rather than passive listeners. Constructivism taps into and triggers the students innate curiosity, about the world and how things work. They become engage by applying their existing knowledge and real world experience, learning to hypothesize, testing their theories, and ultimately drawing conclusions from their findings. Play and Experimentation are self structured and self-motivated forms of learning. Play involves the consideration of novel combinations of ideas and the hypothetical outcomes of imaginal situations and events. It is a form of mental exploration in which children create, reflect on, and work out their understanding in ways generally not promoted by current school curricula. Education works best when it concentrates on thinking and understanding, rather than on rote memorization. Constructivism supports student-directed learning. Student autonomy and initiative are accepted and encouraged. Students are able to clearly cognize the organizing principles they have learned and carry the new knowledge to real life. They also play a part in designing the
assignment patterns. There is much scope for multiple interpretations and expressions of learning. Constructivism supports creativity whereby the students are encouraged to express new knowledge through arts and crafts, models, articles and research papers.

Constructivism provides realistic learning activities that initiate curiosity and prompt students to formulate their own questions (inquiry). Higher level thinking (analyzing, predicting, justifying, and defending their ideas) is encouraged.

Constructivism promotes social and communication skills by creating a classroom environment that encourages group work and the use of peers as resources (collaborative learning). Children who learn together generally learn to live together. What one individual in the group has learned should be the same as that learned by another individual. This emphasizes students ability to solve real life and practical problems.

**Constructivism in schools today**

Constructivism represents a philosophy about teaching and learning rather than one specific approach or practice. Generally adherents of this philosophy believe that children will learn all they need to learn and improve their skills through social interaction and immersion in authentic learning experiences. Some outgrowths of this approach are:
Interdisciplinary Curriculum

Over the past few years, interest in and need for curriculum integration has intensified. Jacobs and Borla present the factors that have propelled this need for curriculum integration. Knowledge continues to grow in exponential rate in all areas of study proving to be both a “blessing and a burden”. Teachers need to think the way to interdisciplinary approach.

Secondly; the behavioural influence of quantification has led fragmentation of the school day. Instead of freedom to fully explore knowledge in authentic ways with their students; teachers increasingly find themselves by artificial constraints of time and subject area Finally; increasing concern over how the irrelevance of curriculum, student life drives toward academic failure has led to an awareness of the need to make meaningful and relevant. Curriculum becomes more relevant when there are connections between subjects and knowledge is presented in unified manner.

The constructivist view that the learning of young people will be facilitated if a rich learning environment of variety of materials that can be touched and handled or provides contact with objects and events outside. The emphasis on student involvement, choice and interest has led to the development of open classroom.

Open classrooms offer a variety of resources such as books on a variety of subjects for free reading, computer programmes, resources and games; learning centres etc., as supplemental resources. Instruction embraces a variety of techniques and resources such as scaffolded
instruction, audio – visual aids, group activities, role – play, field trips and
guest speakers. Instruction is also provided to groups rather than to the
whole group. Children are encouraged to work alone or in small groups on
projects and activities attuned to their interests. These classrooms do have
structure – structure that changes from one hour to the next and the children
join other groups. Constructivism views learning as a socially situated
activity. A number of researchers have concluded that for a deep level
understanding occur only through interaction. This is supported by the work
of Vygotsky, who believes that the internal development that are necessary
for learning, are only able to develop when children are interacting with
people and in co-operation with their peers.

Co-operative Learning groups are heterogeneous groups of children
created to facilitate social communication, collective problem solving,
brainstorming, and construction of meaning.

To be truly effective, there need to be clear academic objectives,
targeting of specific co-operative skills, activity for practice, clear
explanations for how groups are to work together, discussion of individuals,
delineating standards for successful work and establishing a routine.

Discovery Learning

Piaget, Bruner, Dewey and several others grew our understanding
that minds acquire knowledge through an active quest for it. This leads to
the idea that the teacher must engage the mind in that quest to puzzle,
encourage exploration. These general collection of teaching ideas are known as discovery learning (Farnham Diggory 1992).

**Constructivistic Learning**

The theory of constructivism states that learning is non-linear, recursive continuous, complex and rational. It focuses on the learner and each learners perceptions needs and motivation, learning opportunities and the types of teaching and learning experiences that can meet learner needs for success, belonging, and autonomy; learning outcomes that include affective, cognitive, social and performance domains, the learning context or climate of learning including expectations, teacher and technology support, time structures for collaboration, learning partnerships and mentioning relationships and adaptability to student needs. Thus, there is balanced focus on the individual learner (The changing role of the learner from novice to expert, from learner to teacher), the learning process (the dynamic, self-directed and often social nature of that process) and the learning context (the environment, climate and community that supports the learner and the learning process.) This balance addresses the individual learner needs as well as learning needs in general. It provides a whole person view that include cognitive / Meta cognitive, affective / motivational, social / developmental, and other individual needs. It also balances academic and non academic concerns that are part of learning and achievement goals for the 21st century learners; and it acknowledges the importance of the context and learning community that supports both individual learners and the social nature of the learning process.
The basic idea of constructivism is that the learner must construct knowledge; the teacher cannot supply it (Bringuer 1980).

Constructivism is an approach in which the learner is building an internal illustration of knowledge, a personal interpretation of experience. It is active, constructive, cumulative, goal-directed, diagnostic and reflective (Simons 1993). Constructivism emphasizes the careful study of the processes by which children create and develop their ideas. Such a type of learning encourages student-faculty contact, encourages co-operation among students, encourages active learning, gives prompt feedback, emphasizes time on task, communicates high expectations and respects diverse talents and ways of learning. Constructivism can transform thinking and practice beyond today’s traditional models and boundaries of schools and educational systems. Rather than simply absorbing ideas spoken to them by teacher or some how internalizing them through endless, repeated role practice, constructivism posits that children actually invent their ideas. Such a type of learning encourages students-faculty contact, encourages co-operation among students, encourages active learning, gives prompt feedback, emphasizes time on task, communicates high expectations and respects diverse talents and ways of learning constructivism can transform thinking and practice beyond today’s traditional systems. Rather than simply absorbing ideas spoken to them by teachers or some how internalizing them through endless, repeated rote practice, constructivism posits that children actually invent their ideas.
The constructivist view involves two principles:

- Knowledge is actively constructed by the learner, not passively received from the environment.
- Coming to know is a process of adaptation based on and constantly modified by a learner’s experience of the world. It does not discover an independent, pre-existing world outside the mind of the knower.

Four epistemological assumptions of constructivist learning are:

- knowledge is physically constructed by learners who are involved in active learning.
- knowledge is symbolically constructed by learners who are making their own representation of action;
- knowledge is socially constructed by learners who convey their meaning making to others.
- knowledge is theoretically constructed by learners who try to explain things they do not completely understand.

Constructivism is a philosophy of learning that “refers to the idea that learners construct knowledge for themselves each learner individually (and socially) constructs meaning as he or she learns (Hein 1991) In other word, “students construct their own knowledge based on their existing schemata and beliefs” (Walsh 1997)
Role of teachers in constructivistic context of learning

In the constructivist classroom, the role of teacher also demands new orientation to suit the modern temper and times. Almost all students in one way or another construct their own meanings while acquiring knowledge. It is a very valuable mental activity of pupils, which should not be ignored thoughtlessly. It is then up to the pupils to link and interlink concepts by developing strategies to help themselves in construction of their new knowledge. This in other words, means that knowledge is constructed and reconstructed progressively in the presence of the teacher.

The teacher becomes a guide for the learner, providing bridging or scaffolding, helping to extend the learner's zone of proximal development. The student is encouraged to develop met cognitive skills such as reflective thinking and problem solving techniques. The independent learner is intrinsically motivated to generate, discover, build and enlarge her/his own framework of knowledge. The teacher is a facilitator or coach in the constructivist learning approach. The teacher guide the student, stimulating and provoking the student's critical thinking, analyzing and synthesizing throughout the learning process. The teacher is also a co-learner.

More emphasis is on organizing and meaningful learning than mechanical learning, emphasis on improvement of thinking than the attainment of narrowly conceived specific understandings and skills will be laid by the teacher. Right concept formation, application of scientific knowledge to unknown situation, designing and executing varied problem solving procedures are encouraged in the learning process. Over all, a swing towards self-study, self-understanding and self-education among students
rather than authoritarian or dominated teaching learning process by teachers is found in a constructivist classroom

What the constructivist teacher has to do in his classroom

Constructivist teacher has to use many techniques in the teaching process. For ex: he may.

- Prompt students to formulate their own question (Inquiry)
- Allow multiple interpretations and expressions of learning (Multiple Intelligences)
- Encourage group work and the use of peers as resources (Collaborative learning)

Its primary goal is helping students learn how to learn

Instructional Strategies :

A teacher adhering to the constructivist theory has a wide array of instructional techniques to choose from. They are listed below.

**Scaffolding** : To scaffold means to bridge the gap between where the learner is presently in achievement and some higher ideal or goal. The goal can only be attained through instruction. It is to bridge the gap between the known and unknown. This is a procedure by which the teacher provides supports that students cannot yet provide. The student presents ideas; the teacher raises issues that the student has not considered.
Exploration and Reflection:

In this procedure the teacher pushes the students into new domains of requiring them to manipulate, interact, talk and figure out a situation. Reflection is a process that encourages the students to engage in while exploring or subsequent to exploration when students mentally go over their experiences to gain insight.

Brainstorming:

This is one of a number of techniques in which a problem is posed and students are encouraged to find as many solutions as possible. They seek many different solutions.

Constructivist classroom:

In a constructivist classroom, learning is constructive students are not blank states. They come to learning situations with already formulated knowledge, ideas and understandings. This previous knowledge is the raw material for the new knowledge they will create.

Active:

The student is the person who creates new understanding for him. The teacher coaches, moderates, suggests but allows the students to experiment and ask questions. Learning activities require the student's full participation.
Reflective:
Students control their own learning process, and they lead the way by reflecting on their experiences, this process makes them experts of their own learning. The teacher helps create situations where the students feel safe questioning and reflecting on their own processes, either privately or in group discussions. The teacher should also create activities that lead the student to reflect on his or her prior knowledge and experiences. Talking about what was learned and how it was learned is really important.

Collaborative:

The constructivist classroom relies heavily on collaboration among students. The main reason it is used so much in constructivism is that students learn about learning not only from themselves but also from their peers. When students review and reflect on their learning processes together, they can pick up strategies and methods from one another.

Inquiry based:

The main activity in a constructivist classroom is solving problems. Students use inquiry methods to ask questions investigate a topic and use a variety of resources to find solutions and answers and students explore the topic, they draw conclusions and as exploration continues they revisit those conclusions. Exploration of questions leads to more questions.
Evolving:

Students have ideas that they may later see were invalid, incorrect or insufficient to explain new experiences. These ideas are temporary steps in the integration of knowledge. For instance, a child may believe that all trees lose their leaves in the fall, until he/she visits an evergreen forest. Constructivist teaching takes into account students current conceptions and builds from there.

Constructivism emphasizes that powerful gains are made when children work together. It is not enough to memorize lecturer notes; students must understand what they learn and critically evaluate the same by employing higher level learning processes. When children collaborate, they share the process of constructing their ideas, instead of simple labouring individually. The advantages of this collective effort are that the children are able to reflect on and elaborate not just their own ideas, but those of their peers as well. Children come to know their peers not as competitors but as resources. Mutual tutoring, a sense of shared progress and shared goals and a feeling of teamwork are the natural outcomes of collaborative problem solving environment. These processes have been shown to produce substantial advances in learning - centred education. The focus of the constructivist attitude is the child as a self governed creator of knowledge. To accomplish this, a supportive environment, one in which he/she can create his/her own ideas, both individually and collaboratively must be provided.
Ten points are offered to characterize a science classroom where the constructivist model can work best.

**Such classrooms are those that:**

- Use student identification of problems with local interest and impact as organizers for the course;
- Use local resources (human and material) as original sources of information that can be used in problem resolution;
- Involve students in seeking information that can be applied in solving real-life problems;
- Extend learning beyond the class period, the classroom, and the school;
- Focus on the impact of science on each individual student;
- Refrain for viewing science content as something that merely exists for students to master on tests;
- De-emphasize process skills as the "special" skills that should be mastered because they are used by practicing scientists;
- Emphasize career awareness — especially careers related to technology;
- Provide opportunities for students to perform citizenship roles as they attempt to resolve issues they have identified.
Strategies adopted in constructivist teaching:

- Invitation
- Observe surroundings for points of curiosity
- Ask questions
- Consider possible responses to questions
- Note unexpected phenomena
- Identify situations where student perception vary
- Exploration
- Engage in focused play
- Brainstorm possible alternatives
- Design a model
- Look for information
- Evaluate choices
- Experiment with materials
- Engage in debate
- Observe specific phenomena
- Analyze data
- Employ problem – solving strategies
- Collect and organize data
- Define parameters of an investigation
- Identify risks and consequences
- Select appropriate resources
- Discuss solutions with others
- Design and conduct experiments
- Propose explanation and solutions
• Construct and explain a model
• Utilize peer evaluation
• Assemble multiple answers / solutions
• Determine appropriate closure
• Review and critique solutions
• Communicate information and ideas
• Integrate a solution with existing knowledge and experience
• Taking action
• Ask questions
• Apply knowledge and skills
• Share information and ideas
• Transfer knowledge and skills
• Make decisions
• Develop products and promote ideas
• Use models and ideas to illicit discussion and acceptance by others.

**Teaching using the 5E’s:**

The 5E’s learning cycle is a method of structuring a lesson that is based upon constructivistic learning theory. It is a recursive cycle of distinctive cognitive stager of learning that include Engage, Explore, Explain, Extend and Evaluate.
The first stage is the “Engage”. This is the introduction to the lesson that motivates or books the students interest in the learning to follow it can be a demonstration, a discussion, a reading or other activity used to tap into prior knowledge about the lesson and engage the student’s curiosity. It is used to idea on implementing a constructivist format.

‘Explore’ activity allows the students to have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. They observe, question and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.

The ‘Explain’ stage encourages students to explain concepts and definitions in their own words. Students are asked to justify and clarify their ideas. Formal definitions, explanations and levels are provided. This is done through such activities as discussions, chalk, talks, film etc., and can be didactic in nature.

The ‘Extend’ stage allows students to apply their new labels, definitions, explanations and skills in new but similar situations. It often involves experimental inquiry, investigative projects, problem solving and decision making. Lab work is common. Students frequently develop and complete their own well designed investigations.

The ‘Evaluate’ stage assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies. Teachers frequently observe students as they apply new concepts and skills to assess student’s knowledge and/or skills, looking for evidence that the students
have changed their thinking or behaviors. The opportunity to allow students to assess their own learning and group process skills is often provided.

Basically, constructivism view that knowledge is not ‘about’ the world, but rather ‘constitutive’ of the world (Sherman, 1995). Knowledge is not a fixed object, it is constructed by an individual through her own experience of that object. Constructivist approach to learning emphasizes authentic, challenging projects that include students, teachers and experts in the learning community. Its goal is to create learning communities that are more closely related to the collaborative practice of the real world.

In an authentic environment, learners assume the responsibilities of their own learning. They have to develop Meta cognitive abilities to monitor and direct their own learning and performance. When people work collaborating in an authentic activity, they bring their own framework and perspectives to the activity. They can see a problem from different perspectives and are able to negotiate and generate meanings and solutions through shared understanding.

The constructivist paradigm has led us to understand how learning can be facilitated through certain types of engaging, constructive activities. This model of learning emphasizes, meaning making through active participation in socially, culturally historically and politically situated contexts. A crucial element of active participation is dialog with shared experiences, such as modeling, discourse and decision making are necessary to support the negotiation and creation of meaning and understanding.
Traditional vs Constructivistic approach

The classroom is no longer a place where the teacher pours knowledge into passive students, who wait like empty vessels to be filled in. in the constructivist model, the students are urged to be actively involved in their own process of learning. The teacher functions more as a facilitator who coaches, mediates, prompts and helps students develop and assess their understanding, and there by their learning. The table below compares the traditional classroom to the constructivist one.

Brooks and Brooks (1993) offered an interesting comparison of the visible differences between “traditional” classroom and “constructivist” classrooms. Their comparison is as follows:

- Students primarily work in groups unlike individually as in traditional classroom.

- Curriculum is presented whole to part with emphasis on the big concept whereas in traditional classroom it is vice versa.

- Pursuit of student questions is highly valued whereas in traditional classroom strict adherence to a fixed curriculum is valued.

- Curricular activities rely heavily on primary resources unlike relying only on textbooks.

- Students are viewed as thinkers with emerging theories about the world (Cognitive apprentices) unlike its counterpart.
• Teachers are information dispensers and assess only to validate student lessons in traditional classroom whereas a constructivist teacher generally behave in interactive manner mediating the environment for students and seeks student’s point of view in order to understand student learning for use in subsequent conceptions.
<table>
<thead>
<tr>
<th><strong>Traditional classroom</strong></th>
<th><strong>Constructivist classroom</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral psychology</td>
<td>Cognitive psychology</td>
</tr>
<tr>
<td>Curriculum is presented part to whole, with emphasis on basic skills</td>
<td>Curriculum is presented whole to part, with emphasis on big concepts</td>
</tr>
<tr>
<td>Curricular activities rely heavily on text books and workbooks</td>
<td>Curricular activities rely heavily on primary sources and manipulation of data and materials.</td>
</tr>
<tr>
<td>Students Practice skills and memorise information</td>
<td>Students actively pursue learning and construct knowledge</td>
</tr>
<tr>
<td>Students primarily work alone</td>
<td>Students primarily work in groups.</td>
</tr>
<tr>
<td>Students are viewed as “blank states” onto which information is transmitted by the teacher</td>
<td>Students are viewed as thinkers with emerging theories about the world.</td>
</tr>
<tr>
<td>Teachers generally behave in a didactic manner.</td>
<td>Teachers generally behave in a dynamic manner, mediating the environment of students.</td>
</tr>
<tr>
<td>Teachers seek the correct answer to validate student learning of content knowledge and skills.</td>
<td>Teachers seek the students point of view in order to understand students view and develop ideas for use in future lessons.</td>
</tr>
<tr>
<td>Assessment of student learning is viewed entirely through testing.</td>
<td>Assessment of student learning is interwoven with observations of students work and through student performance and portfolios.</td>
</tr>
<tr>
<td>Learning is expected to be uniform, the same for everyone.</td>
<td>Learning is expected to be individual, different for everyone.</td>
</tr>
</tbody>
</table>

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Myths of constructivism

The first myth of constructivism is that “students should always be actively and reflectively constructing” (elements, 1997). A second myth or misunderstanding is that memorization and rote learning are useless”. Quite simply, there is certain knowledge that cannot be received by the learner any other way. The instructor must be aware that “right balance between the activities of constructing and receiving knowledge” is attained. A third misconception about constructivism is that learners are lonely voyagers “students do not construct knowledge alone, even though each has to modify his or her own ways of thinking and acting”. A fourth misunderstanding of constructivism is that everybody is right”.

Nature of Science and Science Teaching

Science as an enterprise has individual, social, and institutional dimension. It is fundamentally a means of a means of understanding why things happen as they do. Man has found science as a process by which his search for answers to his unlimited questions can be approached systematically. In this way the study of science is an intellectual and social endeavor – the application of human intelligence in figuring out how the world works, should have a prominent place in any curriculum that has science literacy as one of its aims.

Bullock (1976), a historian has deemed science to be ‘the greatest intellectual and cultural achievement of modern man’. He perceived science as an open-ended process in which imagination, hypotheses, criticism and
controversy take a dominant role. It is not, nor was it ever, 'the closed
dogmatic system of immutable laws. Bullock sees science as a humane
activity, deeply concerned with man and society, providing scope for
imagination and compassion as well as for observation and analysis.

Conant (1951), an eminent scientist and an educator also defined
science as “an interconnected series of concepts and conceptual schemes that
have developed as a result of experimentation and observation and are
fruitful to further experimentation and observation”.

Science thus, is simultaneously a body of knowledge and a way of
gaining and using that knowledge. The accumulated and systematized body
of knowledge, which is the 'product' of science – has a dynamic counterpart,
the scientific attitudes and methods of inquiry—which is the 'process' of
science. Science thus is a combination of both 'processes' and ‘products’
related to and dependent upon each other. When, used in this way, science
offers methods of inquiry useful in learning more about the universe and its
workings. The interrelation and expanding nature of the processes and
products of science is shown in the following figure.
Fig. 1.3.: Inter-relationship between scientific processes and products

Source: Carin and Sund (1964)

NEW INVESTIGATIONS OF PHENOMENA IN NATURE

INVESTIGATION OF PHENOMENA IN NATURE
Objects Events Relationship etc.

NEW SCIENTIFIC PRODUCTS

SCIENTIFIC PROCESSES

Attitude
Intense curiosity
Humility
Skepticism
Determination
Open mindedness etc.

METHODS
Identifying problems
Observing
Hypothesizing
Analysis
Inferring
Extrapolating
Synthesizing
Evaluating etc.

SCIENTIFIC PRODUCTS
Facts
Concepts
Generalizations
Principles
Theories
Laws

SCIENTIFIC PROCESSES
The processes of science include scientific attitudes and methods of inquiry. Scientific attitudes include both emotional attitudes such as curiosity, humility, determination, open mindedness and intellectual attitudes namely objectivity, skepticism and rationality. The methods of inquiry are observing, hypothesizing, analyzing, inferring, extrapolating, reasoning and synthesizing etc. The scientific attitudes develop simultaneously with science process skill development and with the discovery or construction of useful science ideas. The information and ideas of science that compose its knowledge base are often referred to as ‘products’ since new discoveries add to the base of scientific information which are the products of curiosity and experimentation. An interesting thing about science knowledge is that new discoveries often lead to more questions, more experiments, and further discoveries. The science cycle move under its own momentum propelled initially and again later sustained by human curiosity and a desire to explain natural phenomena. The effect is an exploding accumulation of new information that is added to the knowledge base. Scientific knowledge consists of primarily facts, concepts, principles and theories. The scientific theories are refined in the light of new ideas which Kuhn (1970) called a new paradigm.
It is a well-known fact that children are curious. Their curiosity motivates them to discover new ways to use this powerful key for unlocking the mysteries of their world. As said earlier, both the products and processes for acquiring them are to be experienced by the students. Children receive a whole science experience when they are immersed in all the three parts of science. The synergy among the parts which makes science whole is shown in the Science cycle given in fig. 1.4.
Attitudes are mental predispositions towards people, objects, events and so on. In science, attitudes are important because of three primary factors. First, a child's attitude carries mental state of readiness with it. With a positive attitude the child will perceive science objects, topics, activities and people positively. Secondly, attitudes are not innate or inborn. They are learned and organized through experiences as children develop. Thirdly, attitudes are dynamic result of experiences that act as directive factors when a child enters into new experiences. As a result, attitudes carry an emotional as well as an intellectual tone. Attitudes not only improve achievement, but also build up interest and self esteem which is represented in the following diagram.

**Fig. 1.5: Importance of Basic Science Attitudes**

*Source: Adapted from Benjamin Bloom, Human characteristics and school learning (New York: McGraw – Hill, 1979)*
It is essential to distinguish between the two broad subsets of science related attitudes. Attitude towards science, according to Duckworth (1975) refers to the "disposition of mind for or against scientists, scientific activity and learning of science" and has predominantly affective orientation. On the other hand, scientific attitude is "the cognitive attitude or belief about thinking and has also affective and behavioural aspects" (Guilford, 1978). Grinell had listed down around 20 scientific attitudes namely; empiricism, determinism, a belief that problems have solutions, parsimony, scientific manipulation, skepticism, precision, respect for paradigm, a respect for power of theoretical structure, willingness to change opinion, loyalty to reality, aversion to superstition and an automatic preference for scientific explanation, a thirst for knowledge, an "intellectual drive", suspended judgment, awareness of assumptions, ability to separate fundamental concepts from the irrelevant or unimportant, respect for quantification and appreciation of mathematics, an appreciation of probability and statistics, an understanding that knowledge has tolerance limit and empathy for the human condition.

Apart from the knowledge and attitudes, there is one more part of science i.e. science process skills. Children learn how to learn by thinking critically and using information creatively. They continue to learn how to learn when making discriminating observations, when organizing and analysing facts and concepts, when giving reasons for expected outcomes, when evaluating and interpreting the results of experiments and when drawing justifiable conclusions (Victor, 1971). In science, the ways of thinking, measuring, solving problems and using thoughts are called
processes. Process skills describe the type of thinking and reasoning required.

Science process skills may be divided into two types: basic and integrated skills. Basic skills include observing, classifying, communicating, measuring, estimating, reasoning, predicting and inferring. Integrated skills include identifying, controlling variables, defining operationally, hypothesizing, experimenting, graphing, interpreting, modelling and investigating.

Science process skills along with science related attitudes lead to discovery of scientific knowledge that is the product side of science. Scientific knowledge is tentative. A scientific finding or a prediction, which is accepted to be true at a particular time, is probabilistic and not absolute. It is derived from imagination, observation and experimentation. Scientific knowledge is rational and empirical i.e. it has origin in the real world, and dependent on sense experiences. It is holistic; the knowledge gathered by various branches of science contribute to an overall conceptual scheme or mental construct, which is internally consistent. As a product of creative human imagination, concepts of science reflect the social and cultural background of their times.

The values that underlie science represent the very human origin itself. It can be argued that without these values, the enterprise of science could not have occurred. They are,
• Consideration of consequences --- decision based on the assessment of the effects emanating from an action or a set of actions.
• Longing to know and understand.
• Demand for verification --- search for supporting evidence to verify the validity and accuracy of a statement.
• Questioning --- belief that all things, including "self-evident" truths are open to question.
• Respect for logic --- consideration of influences that emerge from cause-effect relationships.
• Search for data and their meanings.

Why teach science in school? or more importantly --- Why should young people at school attempt to learn it? There are a number of responses to these questions. Association for Science Education (ASE, 1981) gave explanations to these questions, as science is both deeply interesting and beautiful in construction. The pursuit of knowledge in science is an end in itself, an intellectual activity leading to the creation of further research and knowledge. Science is a part of the world of ideas; its history, philosophy, literature, pedagogy and social institutions contribute to the culture of our societies. Science has high utilitarian value. High achievement in science can lead to a wide range of life chances, active participation in the process of democratic decision-making, understanding how some principles and laws in science can provide a basis for rational choice in life contexts.

Learning of science in schools augments the spirit of enquiry, creativity and objectivity along with aesthetic sensibility. It aims to develop well-defined abilities of knowing, doing and being. It also nurtures the
ability to explore and seek solution of the problems related to the environment and daily life situations and to question the existing beliefs, prejudices and practices in society. Thus science is must for every child to learn as it gives an opportunity to learn how to learn. In India the inclusion of science as a discipline and improvement in the science education is the successful effort of various committees and commissions.

One of the oldest commissions, University Education Commission (1948) felt that improvement of curriculum and syllabus at the secondary level is essential for the improvement of University Education and recommended the inclusion of science as a discipline at secondary level. Later, Secondary Education Commission (1953) suggested compulsory inclusion of general science and mathematics as core subjects at the middle school as well as secondary level. Then, the Indian Education Commission (1964-66) identified the need of a revolution in the educational system through internal transformation by relating it to the life needs and aspirations of the nation, by achieving qualitative improvement, by expanding educational facilities and by relating education to productivity and recommended science as an integral part of education. Science teaching was ‘to promote an ever deepening understanding of basic principles; to develop problem solving and analytical skills; to inculcate ability to apply them to the problems of the natural environment and social living and to promote the spirit of inquiry and experimentation’. Overall, it heralded a major shift in the school science policy from a general science approach to structure of discipline approach.
During the period 1967-72, efforts were mounted to implement the recommendations of UNESCO Planning Commission (1964) and Education Commission (1964-66). Besides this, The Planning Group Education (1968) gave high priority to the development of science education by laying emphasis on the development of scientific attitudes and skills. In 1972, a variety of materials such as Physical Science Study Committee (PSSC), Biological Science Study Committee (BSSC), School Mathematics Study Group (SMSG) and Chemical Bond Approach (CBA) etc. were produced. Again, the period 1972-77 was a watershed for the school science education policy in our country. Entirely new approaches of teaching science emerged in schools.

Considerable effort was made at national level by NCERT (1961) to improve the quality of science education. Revision of the science curriculum, providing in – service training for science teachers on the new approaches of teaching and evaluation were the major focused areas. According to the 42nd amendment of the Constitution of India ---Part IVA fundamental duties of citizen 51A(h), it shall be the duty of every citizen of India to develop the scientific temper, humanism and the spirit of enquiry and reform (1976).

Based on the recommendations given by the above committees and commissions, the following main objectives of science teaching were arrived for secondary schools.
The teaching of science at secondary level should aim at acquisition of:

- Knowledge of fundamental principles and concepts useful in daily life.
- Skills of experimentation, construction, observation, drawing and problem solving and invention.
- Ability in the students such as ability to sense a problem, to organize, interpret, analyse, generalize, predict from given data, organize science exhibition, fairs etc.
- Inculcating interest in the environment they live in.
- Scientific attitudes like critical thinking, open-mindedness, curiosity, objectivity, free from superstitions and false beliefs, willingness to suspend judgments, belief in cause and effect relationship, rationality etc., and interests.
- A broad genuine appreciation of what development of science means to modern, social, industrial and national life and preparing the students for better living i.e. forming basis for vocational career.
- Train the students for reflective thinking.

**Role of Constructivist Approach in Science Classroom**

A constructivist learning setting differs from the one based of the traditional model. In a constructivist classroom, learning outcomes not only depend on the learning environment but also on the knowledge of the learner. Learning involves the construction of meanings by students from what they see or hear may or may not be those intended. It is a continuous and an active process, which is influenced to a large extent by existing
knowledge. Firstly, current ideas of pupils are elicited using several strategies. These include pupils writing, expressing orally, card-sorting exercises, presenting pupils with description of events and asking them to decide whether they are true or false, pupils producing posters on a particular idea. In this regard, Driver et. al. (1994) identified five possible forms, depending on the outcome of the elicitation phase. These are:

- Developing existing ideas (if no misunderstandings are apparent);
- Differentiating between existing ideas (where two or more scientific ideas may be seen as one by pupils, e.g. dissolving and melting);
- Integrating existing ideas (where pupils may hold several ideas relating to one scientific idea);
- Changing existing ideas (where pupils hold ideas which differ from the scientifically accepted ideas); and
- Introducing new ideas

After elicitation phase, the most difficult thing is changing existing ideas. Among the various methods, the most prominent ones are Socratic questioning and introducing discrepant event in order to induce cognitive conflict, disequilibrium or dissonance in the minds of pupils. These approaches will help in the modification of existing ideas and in construction of new situations. Later, the new idea is compared with previous ideas. Thus, meanings, once constructed, are evaluated and can be accepted or rejected. Learners take the final responsibility of their learning (Driver and Bell, 1986). The process of construction of new ideas is shown in the fig. 1.5.
During the process of learning the students actively participate in various activities both individual and group work; share their feelings and ideas, reconstruct the meanings whenever required. There is no single approach or strategy used in a constructivist classroom, it is an eclectic approach made use of with a variety of methods, strategies and techniques but following the principles of constructivist approach. During the process of construction of meanings, the students make use of various process skills and develop positive attitudes. There is every chance provided to practice and understand the nature of science and inculcate scientific attitude among the students.
Fig. 1.6 The Constructivist Teaching Model Developed by the Children’s Learning in Science Project Team.

Source: Driver and Oldham (1986).
Various educators and cognitive psychologists have applied constructivism to the development of learning environments.

Jonassen (1991) isolated a number of design principles:

• Create real-world environments that employ the context in which learning is relevant;

• Focus on realistic approaches to solve real-world problems;

• The instructor is a coach and analyzer of the strategies used to solve these problem;

• Stress conceptual interrelatedness, providing multiple representations or perspectives on the content;

• Instructional goals and objectives should be negotiated and not imposed;

• Evaluation should serve as a self-analysis tool;

• Provide tools and environments that help learners interpret the multiple perspective of the world;

• Learning should be internally controlled and mediated by the learner.
Wilson and Cole (1991) provide a description of cognitive teaching models, which "embody" constructivist concepts. The following concepts central to constructivist design, teaching and learning were isolated:

- Embed learning in a rich authentic problem-solving environment;
- Provide for authentic versus academic contexts for learning;
- Provide for learner control;
- Use errors as a mechanism to provide feedback on learner's understanding.

1.1 Rationale and significance of the study

The aims and objectives of science education at secondary level spelt out were unfortunately not implemented properly. In spite of the effort made by many committees and commissions as listed earlier, the quality of science education is not satisfactory. After the National Curriculum framework, there is a change in the textbooks, role of the teacher, and involvement of the community and so on. The textbooks are activity based; inclusion of learner centered teaching learning process and increased utilization of community resources. National Council of Educational Research and Training (NCERT) emphasized viewing the child as a constructor of knowledge. Learning of science up to secondary stage needs to be replaced by learning of science and technology in view of strong organic linkages between the two. It also recommended the following:
• Scientific attitudes and skills should be developed.

• Students are needed to be exposed to the nature and structure of science and the support it provides to the technological developments.

• Learning of science should be built around natural and social elements of environment.

• Focus would be on understanding of concepts and applications in the areas of matter and its properties, energy, relationship of various physical processes and the technological applications of principles of science.

• Science, technology, society and environment would coalesce in teaching and learning of science at secondary stage.

• Practical activities to be chosen should have relevance for further life through acquisition of skills and values.

• Emphasis on the “learner centered approach” commensurate with the physical, mental, social and emotional development of learners in relevant age groups. In other words, there needs a shift of emphasis from information based and teacher centered education to process centered and learner friendly education. Learners are needed to be encouraged to work both individually as well as in groups.

• Critical, creative and generative thinking has to be developed.

• Improvisation should be encouraged but designing would also be provided as a component in exploration.
• Flexibility in experimentation needs to be widely promoted.

• Teachers could help the learners devise appropriate experimentation and activities within and outside the school.

The present science education is far away from the above vision. Science is being taught in the schools as a body of established facts obtained by individuals using infallible methods. The present classroom practices emphasize on the product side of science rather than the method of acquiring the knowledge, which is the scientific method that forms the process side of science. In spite of several recommendations by many associations, AAAS (American Association for the Advancement of Science), SAPA (Science A Process Approach), NSTA (National Science Teachers Association) to develop science process skills, science related attitudes, understanding of nature of science along with acquisition of knowledge, still there is a very little chance provided to the learners to acquire the above.

In the conventional classroom, the classes are usually driven by teacher talk and depend heavily on textbooks for the structure of the course. Teacher serves as pipelines and seek to transfer their thoughts and meanings to the passive students. Thus there is little room for student initiated questions and independent thought and interaction between students. They emphasis the learning of answers more than the exploration of questions, memory at the expense of critical thought, bits and pieces of information instead of understanding in context, recitation over argument, reading in lieu of doing. They fail to encourage students to work together, to share ideas
and information freely with each other, or to use modern instruments to extend their intellectual capabilities. Above all, there is no scope of understanding the misconceptions found among the students in the conventional method of teaching science.

Apart from the above observations it was also found that the teachers do not concentrate on the process of learning by students and also overlook the misconceptions among them. The Chinese proverb “Do not give fish but teach them how to catch a fish” can be remembered here. Teaching the children how to learn is important than providing the facts to them. It is expected to raise the application abilities among the children learning science and technology to meet the aspirations of the day. Besides this, in the present competing world, there is a need of objective, critical and an intellectual mind i.e., a proper scientific attitude.

All the above ideas and process occur repeatedly in constructivist writings. Even the students who score well are unable to successfully integrate or contrast memorized facts and formulate real life applications outside the school room (Yager, 1997). It was also found that practical knowledge and school knowledge are becoming mutually exclusive; many students see little connection between what they learn in the classroom and with their real life.

One proposed solution for the problem is to prepare students to become good adaptive learners. Obviously the traditional teacher as information giver, textbook guided classroom has failed to bring about the desired outcomes of science education. An alternative is to change the focus of the classroom from teacher dominated to student centered using a constructivist approach is effective in the development of science attitudes and achievement by using various methods and strategies.
An attempt was made to study the effectiveness of constructivist approach in Indian context at secondary school level to find out whether this method would improve the students understanding of nature of science, demonstrate a superior understanding of basic science concepts, use and understand basic processes of science better, can apply science concepts and processes in new situations, have more positive attitudes of science, science study and science teachers, develop better science process skill including observing, reasoning, inferring, interpreting, proposing solutions, and predicting consequences, have more complete views of the nature of science.

1.2 Statement of the problem

Constructivism is a view of learning based on the belief that knowledge is not a thing that can be simply given by teacher at the front of room to students in their desks. Rather, learners through an active, mental process of development construct knowledge; learners are the builders and creators of meaning and knowledge. The teacher is a co-participant, facilitator unlike the conventional one. The student is an active participant who explores, constructs the meaning, explains it and expands the knowledge with the help of questions posed by the teacher. Constructivist approach is a pupil-centered method of teaching.

The present investigation is titled as “Effectiveness of constructivist approach on students’ achievement in science, science related attitude, science process skills and perception of nature of science at secondary level”
Operational definitions of the terms used

A number of terms and concepts have been used in the study. To convey the specific meaning, the terms and concepts used in the present study have been defined operationally as follows.

Constructivist approach

Psychological constructivist approach is based on Jean Piaget's model of the development of the individual. The process focuses learning as a personal, individual, intellectual construction based on experiences of one in the world. Learning by doing and forming ideas from one's exploration is the underlying theory behind psychological constructivism. In this approach, the child is viewed like a scientist who possesses insights, questions, solves problems, experiments, explores and so on. During the process, the child learns many skills like observing, hypothesizing, inferring etc., which in turn develops a scientific mind and positive attitude towards science, the main objectives of teaching science.

ii) Achievement in science

Achievement indicates the attainment of the objectives like knowledge, understanding, application and skill. An achievement test in the selected content including all the above four levels of objectives was constructed by the investigator. Thus achievement in science in the present study is the total score obtained by the students in the achievement test constructed by the investigator.
iii) Perception of Nature of Science

Perception of nature of science means the way the students perceive and understand the nature of science. In the present study, perception of nature of science pertains to the following aspects:

- characteristics of science
- scientific methods/processes
- use of scientific discoveries
- application of science in daily life
- role of science in society and its impact on human beings

iv) Science process skills

In science, the ways of thinking, measuring, solving problems and using thoughts are called processes. Among the various basic and integrated skills, the following intellectual skills were selected for the present study.

- Observing
- inferring
- predicting
- hypothesizing
- interpreting and reasoning

The science process skills in the present study are the total sum of the above process skills in the developed test.

v) Opinion towards science

Gardner (1975) defined opinion towards science in the following manner: "We may regard a persons Opinion to science as a learned disposition to evaluate in certain ways objects, people actions, situations or propositions involved in learning science"
The term opinion towards science is composed of two words-'opinion' and 'science'. Opinion is the degree of positive or negative effect associated with some psychological object. Object here is “science” as a discipline.

Hence opinion towards science is generalized attitude towards the universe of science content and being measured in terms of its favorableness estimated from the scores obtained by the subject on an opinion scale towards science.

1.3 Variables included in the study:

A) Independent variables:
1) Constructivist approach aims at improving achievement science, perception of nature of science, science process skills, opinion towards science and science related attitude.
2) Gender

B) Dependent variables:
Effect of constructivist approach is studied on the students achievement in science, perception of nature of science, science process skills, opinion towards science and science related attitude.

1.4 Objectives of the study

With an insight into the philosophical, psychological and pedagogical bases of constructivism, the research undertaken aimed to study a few research bearing questions, which may throw light upon constructivism an approach to learning. These are reflected in the form of objectives given below:
• To develop science lessons based on constructivist approach in the selected units of science for Seventh standard students.

• To study the effectiveness of constructivist approach on the students' achievement in science.

• To study the effectiveness of constructivist approach on the students' perception of nature of science.

• To study the effectiveness of constructivist approach in developing science process skills among the students.

• To study the effectiveness of constructivist approach on the students' opinion towards science.

• To study the effectiveness of constructivist approach on the students' science related attitude.

• To study the interaction between 'gender' and 'group' with reference to achievement in science, perception of nature of science, science process skills, opinion towards science and science related attitude.

• To examine the relationship among achievement in science, perception of nature of science, science process skills, opinion towards science and science related attitude.

1.5 Hypotheses formulated for the study

The following research hypotheses were formulated in pursuance of the broad objectives of the study:

H1: The constructivist approach does have a positive effect on the achievement of students in science.
H2: The constructivist approach does have a positive effect on the students’ perception of nature of science.

H3: The constructivist approach does have a positive effect on the development of science process skills among students.

H4: The constructivist approach does have a positive effect on the students’ opinion towards science.

H5: The constructivist approach does have a positive effect on the students science related attitude.

H6: There is an interaction between gender and group on students’ achievement in science, perception of nature of science, science process skills, opinion towards science and science related attitude.

H7: There is a positive relationship among achievement in science, perception of nature of science, science process skills, opinion towards science and science related attitude.

1.6 Summary

The first chapter conceptual framework elaborately presented the theoretical background of the present study. In the next chapter ie the review of related literature, researches related to the present study are reviewed.