CHAPTER II

REVIEW OF RELATED LITERATURE AND STUDIES

2.10. Overview

This chapter details the conceptual framework of the study so as to provide comprehensive analysis of area chosen for the study and to review the related studies. It consists of three sections. The first section is an overview of entire chapter. The second section examines the conceptual framework of constructivism from pedagogical perspective. The third section reviews studies relevant to the problem.

2.20. Conceptual Framework

Constructivism is a broad term used by philosophers, curriculum designers, psychologists, educators, and others to emphasise the active role of the learner in building, understanding and making sense of information through individual and social activity (Woolfolk, 2004). Constructivism is a theory of knowledge which has roots in philosophy, psychology and cibernetics (Glaserfeld, 1991; Glasersfeld, 1989). According to Glasersfeld constructivism is a vast and wooly area in contemporary psychology, epistemology and education. Constructivism is an epistemology, a philosophical explanation about the nature of knowledge (Airasian & Walsh, 1997).

Literature reveals that constructivism is an approach in which learner actively creating or constructing or building or assembling or structuring or inventing their own knowledge, attitude, values and skills of the world through interactions with his/her

A range of psychological theories about learning and understanding fall under the heading of constructivism (Kazdin, 2000). It is an approach to teaching based on research about how children learn (Tileston, 2004). Constructivism is not often used as a generic term to describe theoretical approaches developed in sociology, psychology, political sciences, education and other social sciences (Vianna & Stetsenko, 2006).
Constructivism is not a theory of learning or model for designing instruction. It is fundamentally an epistemology that has affected the way that educators in the past decade conceive of learning (Jonassen, 2006). According to Fosnot (1993) constructivism is not a theory about teaching. It is a theory about knowledge and learning. Drawing on a synthesis of current work in cognitive psychology, philosophy, and anthropology, the theory defines knowledge as temporary, developmental, socially and culturally mediated, and thus non-objective (cited in Reagan, Case & Brubacher, 2000). Constructivism views learning as a process in which students actively construct or build new ideas and concepts based on prior knowledge and new information (Herr, 2008). Constructivism is also described as construction of knowledge in the sense that learners actively construct knowledge (Rajan, 2013; Savasci & Berlin, 2012; Rajan, 2010; Herr, 2008; Khader, 2005), processing through the existing structures (Good & Brophy, 1990), related to the existing knowledge (Rajan, 2013; Savasci & Berlin, 2012; Rajan, 2010; Cakir, 2008; Gupta, 2000), building an internal illustration of knowledge (Reddy & Shyamala, 2005), on the basis of pre-existing knowledge (Allen, 2008; Sridevi, 2007; Cannolly & Begg, 2006; Koohang & Harman, 2005), by connecting new ideas to existing ideas (Bhaskar & Sivakumar, 2011; Munoz Rosario & Widmeyer, 2009; NCF, 2005), based on their own present and past knowledge and experiences (Cohen, Manion & Morrison, 2004), constructing and understanding, sometimes through their own thinking and sometimes in collaboration with others (Harlen, 2006), explore individual’s own ways of making sense of their lives and experiences (Taber, 2010).
2.21. Epistemological Roots of Constructivism

The verb “to construct” comes from the Latin “con struere” which means to arrange or give structure. Ongoing structuring (organising) processes are the conceptual heart of constructivism. Among the earliest recorded proponents of constructivism are Lao Tzu (6th century B. C.), Budha (560-477. B. C.), and Heraclitus (540-475. B. C.). Aspects of constructivist theory can be found among the works of Socrates, Plato and Aristotle (ranging from 470-320. B. C.) all of which speak of the formation of knowledge (Mahoney, 2004). Saint Augustine (mid 300s A. D.) taught that in the search of truth people must depend upon sensory experience. This of course left him out of balance with the Church (Sood, 2004; Crowther, 1997).

The philosophers such as Gimbattista Vico (1668-1744), an Italian professor, emphasised the role of fantasy and myth in human adaptation. He believed that people can only know what they construct for themselves. It is from Vico’s writings that the term constructivism has been taken (Agirawal, 2007; Mahoney, 2004; Crowther, 1997). Immanuel Kant (1724-1804), a German philosopher, emphasized the power of patterns in our thinking, and he regarded ideas as regulative principles in our experiencing. His categories were predecessors of what are now called “constructs” and “schema” (Mahoney, 2004; Weiner, 2003; Oxford, 1997). Kant 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 (Weiner, 2003; Olson & Torrance, 1996; Brooks & Brooks, 1993). Modern day constructivists, perhaps following some of these earlier
epistemological strands asserts that the mind constructs its own meanings, either individually or socially or both (Oxford, 1997).

In 1876 Hans Vaihinger elaborated some of Kant’s ideas. The philosophy of “As if,” Vaihinger argued that the primary purpose of mind and mental processes is not to portray or mirror reality, but to serve individuals in their navigations through life circumstances. Vaihinger said that we live our lives by means of “functional fictions.” This idea would form the cornerstone of Alfred Adler’s theory of individual psychology. Vaihinger’s work would also influence the later writings of ‘Personal construct’ theorist, George Kelly. William James also explored several constructivist themes, and he and several colleagues carried the curiosity of constructivism across the transition from the 19\(^{th}\) to 20\(^{th}\) centuries. Drawing on the dynamic view of learning described by Johann Herbart (1776-1841), Jean Piaget (1896-1980) developed a model of cognitive development in which balance was central (Mahoney, 2004).

The constructivist perspectives are grounded in the research of Jean Piaget, Vygotsky, Bartlett, and Bruner as well as the educational philosophy of John Dewey, to mention a few intellectual roots (Taber, 2010; Koohang & Harman, 2005; Woolfolk, 2004). In short, the theorists include Plato, Vico, Berkley, Locke, Hegel, Kant, Rousseau, Pestalozzi, Piaget, Vygotsky, Von Glasersfeld, Kuhn, Dewey, Freud, Foucault, Derrida, Saussure and Ausubel (Savasci & Berlin, 2012; Taj, 2011; Taber, 2010; Gordon, 2009; Cakir, 2008).

Constructivism has its roots in a reaction against the traditional objectivism, an epistemology based on the assumption that expert knowledge is much closer to reality
than beginners and aim of education is to transmit the knowledge that experts have acquired to the students. Contemporary educational constructivism is a mixture of the supposedly psychological thesis that “children must construct their own knowledge” and the supposedly Kuhnian epistemological thesis that “all knowledge is relative and paradigm dependent” (Mathews, 2002). Most of the theories in cognitive science include some kind of constructivism because these theories assume that individuals construct their own experiences in particular situations (Woolfolk, 2004).

Constructivism continued to grow throughout the second half of the 20th century, and it is now the focus of numerous books and international journals. The rapidity of its growth has sometimes made constructivism seem like a recent development, while in fact, it has been emerging for centuries. In 1996, the society for constructivism in the human sciences was formed to encourage and communicate developments in theory, research, and practice that reflect an appreciation for “human beings as actively complex, socially-embedded, and developmentally dynamic self-organising.” The constructivists include Walter Truett Anderson, Albert Bandura, Jerome S. Bruner, James F. T. Bugental, Donald H. Ford, Viktor E. Frankl, Kenneth J. Gergen, Vittorio F. Guidano, Hermann Haken, Yutaka Haruki, Humberto R. Maturana, Joseph F. Rychlack, Francisco J. Varela, Heinz Von Foerster, Ernst Von Glasersfeld, Walter W. Weiner and scholars from biology, psychiatry, medicine, history, linguistics, neuroscience, philosophy, physics and political science (Agrawal, 2007; Mahoney, 2004; Kazdin, 2000; Brooks & Brooks, 1999).
Review of Related Literature and Studies

2.22. Types of Constructivism

A review of the literature reveals that educationists and researchers focused on various types of constructivism. According to the uniqueness and differences among constructivism the investigator made a preference to describe those as: (1) Cognitive constructivism, (2) Social constructivism, (3) Radical constructivism, (4) Critical constructivism, (5) Personal constructivism, (6) Emancipatory constructivism, and (7) Humanist constructivism.

Cognitive constructivism views learning as an active process in which learners construct new ideas or concepts based on their current/past knowledge (Cannolly & Begg, 2006). It emphasises the individual’s cognitive development. Learning is conceived primarily as an individualistic enterprise. Cognitive constructivism (Rajan, 2013; Savasci & Berlin, 2012; Taj, 2011; Gordon, 2009; Jha, 2009; Cohen, Manion & Morrison, 2004; Windschitl, 2002; Epstein, 2002; Wing-Mui So, 2002; Hruby, 2001; Biggs, 1996) also referred as Psychological or Piaget’s constructivism or Genetic-epistemological or Individual constructivism (Gordon, 2009; Jha, 2009; Harlen, 2006; Vianna & Stetsenko, 2006; Woolfolk, 2004; Raskin & Neimer, 2003; Benedict, 2002; Baveja, 2002; Sharma, 2001; Fox, 2001; Oxford, 1997; Olssen, 1996; Zeevenbergen, 1996), or Developmental constructivism or Exogenous constructivism or Endogenous constructivism (Jha, 2009).

Social constructivism suggests that social interactions, cultural tools, and collaborative or cooperative activities shape individual development and learning (Rajan, 2013; Savasci & Berlin, 2012; Jadallah et al., 2011; Taj, 2011; Taber, 2010; Zee, 2010;
Gordon, 2009; Harlen, 2006; Jha, 2009; Vianna & Stetsenko, 2006; Williamson, 2006; Cohen, Manion & Morrison, 2004; Sood, 2004; Woolfolk, 2004; Baveja, 2002; Benedict, 2002; Dash, 2002; Epstein, 2002; Mathews, 2002; Windschitl, 2002; Wing-Mui So, 2002; Fox, 2001; Hruby, 2001; Sharma, 2001; Oxford, 1997; Olssen, 1996; Zeevenbergen, 1996; Murphy, Selinger, Mounre & Briggs, 1995). Social constructivism is also referred as Socio-historical constructivism (Olssen, 1996), Cultural constructivism (Jha, 2009; Sood, 2004), Pragmatic constructivism (Gordon, 2009; Olssen, 1996), Contextual constructivism (Crowther, 1997), Transactional or situated constructivism (Jha, 2009), Dialectical constructivism (Jha, 2009), Neo-Vygotskian constructivism (Fox, 2001), and Dewey’s constructivism as a mediated process (Oxford, 1997).

Radical constructivism states that knowledge does not reflect an “objective” ontological reality but exclusively an ordering and organisation of a world constituted by our experience (Savasci & Berlin, 2012; Zee, 2010; Gordon, 2009; Jha, 2009; Glasersfeld, 2008; Vianna & Stetsenko, 2006; Sood, 2004; Baveja, 2002; Mathews, 2002; Pon, 2001; Sharma, 2001; Oxford, 1997; Zeevenbergen, 1997; Olssen, 1996; Murphy, Selinger, Mounre & Biggs, 1995; Phillips, 1995; Glasersfeld, 1991; Glasersfeld, 1989).

Critical constructivism looks at constructivism within a social and cultural environment but adds a critical dimension aimed at reforming these environments in order to improve the success of constructivism applied as a referent (Phan, 2011; Gordon, 2009; Jha, 2009; Fleury, 2004; Kincheloe & Weil, 2004; Sood, 2004; Mathews, 2002).

Personal constructivism developed from the works of Kelly and Frankle, emphasises the personal construction of meaning by the individual or each person.
constructing his or her own life meanings (Taber, 2010; Williamson, 2006; Sood, 2004; Wing-Mui So, 2002; Crowther, 1997; Oxford, 1997; Murphy, Selinger, Mourne & Biggs, 1995). Jha (2009) treated Personal constructivism as Trivial constructivism. The Personal constructivist notions are somewhat similar to the principles of Human constructivism (Sharma, 2001; Ornstein & Hunkins, 1993).

Emancipatory constructivism is an extension of social constructivist perspective in which importance is given for reducing inequalities and the exposure of relationship of exploitation and oppression (Sharma, 2001). Emancipatory constructivism is much closer to critical constructivism in its principles and intention.

There are some other types of constructivism such as (1) Iran Najad’s Whole-theme constructivism, Crocket’s Cognitive complexity constructivism (Oxford, 1997); Feustein’s Mediated Learning (Fox, 2001); Trivial or Weak constructivism (Gordon, 2009; Jha, 2009; Sood, 2004; Baveja, 2002); Empirically-Oriented constructivism (Pon, 2001); Reactionary constructivism, Conservative constructivism (Phillips, 1995); Hermeneutic constructivism (Raskin & Neimer, 2003); Metaphysical constructivism and Cybernetic (or Second order) constructivism (Jha, 2009). In the following pages Cognitive Constructivism and Social Constructivism will be elaborated since the study focuses on practises and problems of revised biology curriculum which draws mainly from these two major paradigms. This is done with reference to concept of knowledge, concept of learning process, concept of learner, concept of teacher and concept of classroom transaction.
2.23. Cognitive Constructivism

Cognitive constructivism owes its genesis largely to the Swiss scholar Jean Piaget (1896-1980) and is concerned with thinking and learning. Cognitive constructivism focuses on the internal structure of concepts and individual’s mental processes as the locus of knowledge construction. Cognitive constructivists are interested in individual’s knowledge, beliefs, self-concepts, or identity and focus on building of emotional apparatus or inner psychological life of people. So they are referred in literature as Individual or Psychological constructivists. Some educational and developmental psychologists referred Piagetian kind of constructivism as “First Wave constructivism” or “Solo constructivism” (Savasci & Berlin, 2012; Cohen, Manion & Morrison, 2004; Woolfolk, 2004; Rodriguez & Berryman, 2002).

2.23.1. Theory of Knowledge

Piaget centred his constructivism on genetic epistemology and hence known as Genetic epistemological constructivism. This perspective explained how the individual child develops and elaborates schemata or mental frameworks or how individuals interpret and act according to conceptual categories or schemata. According to Piaget, ‘Schemes’ are existing cognitive structure that organise experience and are developed in interaction with environment (Kail, 1998; Shaffer, 1996; Berk, 1993; Schickedanz, Schickedanz, Hansen & Forsyth, 1993; Beihler, 1974; Kuslan & Stone, 1969). Schemes represent knowledge for operations. That is, a scheme is a cognitive structure for performing an activity. Schemata are the inferred cognitive structures by which children
and adults intellectually organise perceived events into categories based on common characteristics (Glover & Bruning, 1987). People construct logicomathematical knowledge (knowledge of relationships among ideas, objects and events) according to the active process of internal assimilation, accommodation and equilibration. Children’s biological development occurs through organisation and adaptation to the environment and the same occurs through organisation and equilibration (Oxford, 1997). The knowledge is creative, individual and personal (Cohen, Manion & Morrison, 2004). Piaget suggested that human being have two forms of knowledge about the world - - operative and figurative. Operative knowledge is knowledge of how to perform actions such as tying shoes, writing a letter or grading a paper. Figurative knowledge is knowledge of facts that birds have wings, mammals have four chambered heart, and so on (Glover & Bruning, 1987).

2.23.2. The Learning Process

Cognitive constructivism considers learning as a process of adaptation. For adaptation learners actively restructure cognitive structure in highly individual ways, basing fluid intellectual configurations on existing knowledge, formal instructional experiences, and a host of other influences that mediate understanding (Windschitl, 2002). The learners acquire knowledge by grouping similar experiences into Schema that eventually acquire a name or category. When more experiences are added to a structure, more in-depth understanding is developed for that concept. The created interconnected situations help to form larger concepts (Hruby, 2001).
Schemes change constantly, adapting to children’s experiences. During times of rapid cognitive change, however, children are in a state of cognitive dissonance/conflict. This state is called disequilibrium. This occurs when children realise that new information does not fit with their current scheme or their current schemes are not adequate to incorporate the new information (Martin, 2000; Berk, 1993). When disequilibrium occurs, children reorganise their schemes to return to a state of balance called equilibrium. This process of equilibration involves two processes working together; assimilation and accommodation. Assimilation and accommodation are the two complementary processes by which experiences are integrated into cognitive structures (Glover & Bruning, 1987). Assimilation occurs when new experiences are readily incorporated into existing schemes or it is the process of taking in information about the environment and incorporating it into an existing knowledge structure. Accommodation is the process of modifying existing cognitive structures so that the new information may be assimilated into them (Rajan, 2013; Llewellin, 2002; Martin, 2000; Kail, 1998; Schickedanz, Schickedanz, Hansen & Forsyth, 1993; Glover & Bruning, 1987; Kuslan & Stone, 1969).

Piaget refers to equilibrium as a balance between assimilation and accommodation. When structures cannot easily assimilate new experiences, there is an imbalance between assimilation and accommodation. A sense of disequilibrium motivates the person to seek equilibrium. Equilibrium is achieved as stimuli are assimilated into modified or new cognitive structures (Glover & Bruning, 1987). So equilibration is the process by which assimilation and accommodation attempt to balance
each other (Llewellin, 2002; Martin, 2000; Kail, 1998; Schickedanz, Schickedanz, Hansen & Forsyth, 1993; Kuslan & Stone, 1969). To sum up, equilibration is this back-and-forth movement between equilibrium and disequilibrium throughout development (Martin, 2000; Berk, 1993). This indicates new schemes are evolved as a result of adaptation to more complex experiences through equilibration or by modifying old ones. Individual’s present schematic structure is either altered or new ones emerged.

Intellectual growth is a continuous process of equilibrium-disequilibrium states when equilibrium restored the individual is at a higher intellectual level than before. Piaget believed that children actively participate in their cognitive development through equilibrium, which is the child’s system for regulating and integrating the changes brought about by biological maturation, and physical experiences (Glover & Bruning, 1987). In this way intellectual development and learning can be seen as progressive adaptation of individual’s cognitive schemes to the physical environment (James, 1999). The learning leads the child to develop new types of representations (Marcus, 1998).

Cognitive constructivists’ contention is that individuals construct their own knowledge without any reference to the social and cultural contexts (James, 1999). The learning process is self-directed, self-regulated and active. Learning is marked by the learners’ capacities to explore and experiment (Cohen, Manion & Morrison, 2004). Cognitive constructivists emphasised that learning progresses through sensory motor thinking, pre-operational thinking, concrete operational thinking and formal operational thinking, as the developmental stages or patterns that Piaget conceived.
2.23.3. The Learner

Piaget suggested four stages of cognitive development commencing with birth. These are the sensory motor period, the pre-operational period, the concrete operational period, and the formal operational period. A brief description of the intellectual capabilities and limitations of children at the various stages give a clear vision about the place of learner in cognitive constructivism (Blough & Schwartz, 1974; Anderson, Devito, Dyrli, Kellog, Kochendorfer & Weigand, 1970; Kuslan & Stone, 1969; Sund, Trowbridge, Tillery & Olson, 1967).

2.23.3.1. Sensory Motor Period (0-2 years)

Sensory motor period embodies those behaviours not mediated by signs or symbols. The new born’s innate reflexes and schemes are the building blocks of sensory motor intelligence (for example, suck, grasp, look, etc.). No conception of object performance is there at the early stages. Space, time and causality concepts are not present. During this stage the infant progresses gradually from simple reflex actions to symbolic processes through exercising reflexes, learning to adapt, making interesting events, using means achieving ends, experimenting and using symbols. At the end of the period child attains object concept formation, space coordination, causality concept and time concept formation in its basic level. The child learns to see himself/herself as different from the objects around him/her. The child tries to prolong interesting experiences and start to define things by manipulating them (Llewellyn, 2002; Blough & Schwartz, 1974; Stephens & Evans, 1973; Anderson, Devito, Dyrli, Kellog,
2.23.3.2. Pre-operational Period (2-7 years)

During this period the child begins to use symbols to represent various aspects of his/her environment. This adds new dimension in child’s thinking. The child has difficulty to classify tasks, add classes, multiply classes, break down classes, etc. The child has only primitive concept formation (‘pre-concepts’). Pre-operational children cannot comprehend conservation of quantity or mass or volume (Martin, 2000). This period is characterized by egocentrism, centering, irreversibility, state verses transformation, transductive reasoning, and appearance as reality. A brief description of the major limitations is also necessary to enrich the related literature. So, each of them are described in the following pages.

Egocentrism

Pre-operational children are egocentric in perspective. Logical thought is not widely available to pre-operational children. Thinking is based on what they see. They typically believe that others see the world exactly as they do. They cannot comprehend that other people have different ideas and feelings. It is the inability of the child to take others point of view or the child cannot see the objective world and its laws as separate from his/her own wishes and desires (Stephens & Evans, 1973). It is difficult for a child of this period to understand views other than his/her own (Sund, Trowbridge, Tillery & Olson, 1967). They also sometimes credit inanimate objects with life and life like properties, a phenomenon known as ‘animism.’
Centering

Pre-operational stage children have narrowly focused thought or tunnel vision and concentrate only on one aspect of a problem. So they totally ignore other equally relevant aspects related to it (For example, in the conservation experiment, the child focuses only on level of liquid, size of clay, length of row of coin or objects. At the same time child is unable to focus on diameter, volume, amount, weight, act of pouring, act of pressing, etc.) (Blough & Schwartz, 1974; Anderson, Devito, Dyrli, Kellog, Kochendorfer & Weigand, 1970; Sund, Trowbridge, Tillery & Olson, 1967).

Irreversibility

The pre-operational children cannot reverse operations or thinking. It is the inability of the child to return to the point of origin or cannot perform reversible thought. They cannot understand that if the transformation is reversed the objects would be identical (For example, in the conservation experiment, the child cannot think the things take their original form when water poured back or clay pressed back or rearrange the coins, etc.). They can learn that 2 plus 4 equals 6. But they cannot yet make the reverse logical inferences such as 6 minus 2 equals 4 or 6 minus 4 equals 2. Since the concepts of conservation are not yet developed, the child lacks operational reversibility in thought and action (Anderson, Devito, Dyrli, Kellog, Kochendorfer & Weigand, 1970).

State versus transformation

This is the inability of the child to focus on the transformation from one state to another. It means that the child can focus only on the static aspect of an event. For example, in the conservation experiments such as water and jar, clay ball, coin
arrangement, etc. the child cannot focus on the act of pouring of water, act of pressing of clay, act of spreading of coins, etc. If a child is asked to draw all stages of fall of a vertical bar the child fails to draw the intermediate positions of falling (Sund, Trowbridge, Tillery & Olson, 1967).

**Transductive reasoning**

It is the reasoning from particular to particular (For example, if a child sees a tortoise coming out from a forest s/he thinks the forest is full of tortoise).

**Appearance as reality**

Confusion between appearance and reality is a characteristic of pre-operational thinking. Pre-operational children believe that an object’s appearance tells what the object is really like (For example, a child cries when he/she sees his/her brother in a ghoulish-costume. Suppose a child sees a piece of hard rubber looks like food s/he thinks that it is food. The child cannot consider milk as milk when a glass of milk looks brown through coloured glass).

2.23.3.3. **Concrete operational Period (7-11 years)**

In this stage child starts to use mental operations to solve problems to reason. The mental operations are strategies and rules that make thinking more systematic and more powerful. The child acquires logical thought processes or applies operations to concrete problems. The child starts to opt to logical decisions instead of perceptual decisions. Children are tied to personal experiences and they are still unable to deal with abstract materials, hypotheses and verbal propositions. The thinking is concrete rather than abstract but the child can now perform elementary logical operations and make
elementary grouping of classes and relations (Anderson, Devito, Dyrli, Kellog, Kochendorfer & Weigand, 1970). In this stage child can overcome most of the limitations of pre-operational stage. The important sets of concrete operations are: (1) combinativity, (2) reversibility, (3) associativity, (4) identity, and (5) appearance as reality (Llewellin, 2002; Blough & Schwartz, 1974; Anderson, Devito, Dyrli, Kellog, Kochendorfer & Weigand, 1970; Kuslan & Stone, 1969; Sund, Trowbridge, Tillery & Olson, 1967). Each of these operations is briefly explained below.

**Combinativity**

It enables the child to form variety of class relationships, to know that some classes can be included in other classes (classification) and by which two or more classes are combined to larger groups. They can create hierarchies and they can understand relationships within classes (for example, all girls + all boys = all children; A > B and B > C can be combined to new relationship A > C).

**Reversibility**

In the concrete operational stage, the child is able to perform reversible operations. So a child can understand that if the transformation is reversed the objects would be identical (Sund, Trowbridge, Tillery & Olson, 1967). It implies that every mathematical or logical operation can be cancelled by an opposite operation (for example, 7 + 3 = 10 or 10 – 7 = 3 or 10 – 3 = 7).

**Associativity**

One of the major outcomes of this stage of development of the child is that he/she can form classes and groups and relation concepts in which he/she can more effectively
order what he/she encounters in the world (Sund, Trowbridge, Tillery & Olson, 1967). This reasoning allows a child to arrive at answers in many different ways and several classes can be combined in any order [for example, \(1 + 3 + 5 = 1 + (3 + 5)\)].

**Identity**

It is the ability of children to understand existence of a null element which combined with any element or class, produces no change (for example, \(10 + 0 = 10\)). And a quantity can be nullified by combining it with its opposite (for example, \(10 - 10 = 0\) or walking 3 miles east then 3 miles west, the child reach where he/she started from).

**Appearance as reality**

In the concrete operational stage the child overcome the limitation of having the confusion between appearance and reality. In this stage child comes to know that the object’s appearance and reality is different. In this stage the child develops awareness of the principles of conservation. The child can focus on length, width, volume, level, diameter, act of pouring, act of pressing, act of ranking, act of serializing, etc. in the conservation experiments. The child becomes less egocentric and more sociometric in communication. The child is unable to isolate variables, and proceeds from step to step in thinking without relating each link to all others (Anderson, Devito, Dyrli, Kellog, Kochendorfer & Weigand, 1970).

**2.23.3.4. Formal operational Period (11 years & above)**

In this stage the children can apply mental operations to abstract entities and reflexive thinking through hypothetico-deductive reasoning. Formal operations allow children to take a different, more sophisticated approach to problem solving than concrete
operational children. They can solve problems by creating hypotheses and testing them. Through abstract thinking they can verify data, analyse data, and isolate all factors and possible combinations about problem (Llewellyn, 2002; Blough & Schwartz, 1974; Stephens & Evans, 1973; Anderson, Devito, Dyrli, Kellog, Kochendorfer & Weigand, 1970; Kuslan & Stone, 1969; Sund, Trowbridge, Tillery & Olson, 1967).

The characteristics of formal operations are proportional reasoning, isolation and control of variables, probabilistic reasoning, correlational reasoning and combinatorial reasoning. Proportional reasoning is utilized in comparing the relationships between variables, such as distance and mass in balancing weights on a beam. Isolation and control of variables refers to the ability to identify the variables that bear on a given hypothesis and devise ways to ensure that the result of the experiment is caused by the manipulated variable and not by something else. Probabilistic reasoning includes such phenomena as coin tosses, lottery chances, and often include estimating the probability of given occurrences. Correlational reasoning is the process of establishing the presence and degree of relationships between two variables. Combinatorial reasoning refers to the establishing the number of different causal effects possible from interactions of more than one variable (Llewellyn, 2002; Blough & Schwartz, 1974; Anderson, Devito, Dyrli, Kellog, Kochendorfer & Weigand, 1970; Kuslan & Stone, 1969; Sund, Trowbridge, Tillery & Olson, 1967).

The above description makes it clear that the cognitive constructivists’ concern is for individual child, not the child in a social context. The cognitive constructivists portrayed the child as a lone scientist, creating his or her sense of the world. The learning
is internally controlled and mediated by the learner. All knowledge is constructed or invented by the learner (Oxford, 1997) and it is a self-initiated discovery (Shaffer, 1996). Cognitive constructivists describe children as active, inventive explorers who construct knowledge (schemes) and modify these cognitive structures through the process of organisation and adaptation (Kail, 1998; Shaffer, 1996; Berk, 1993; Biehler, 1974; Piaget, 1960).

2.23.4. The Teacher

Teachers guide children to make sense and meaning of their knowledge. Teachers help to nurture students as independent thinkers and constructors of knowledge. Student’s autonomy and initiative are encouraged. Teachers encourage student’s reflective and autonomous thinking. They place the child in an active, initiative and discovery role. Consider the limitations of children as natural and arrange learning situations according to the intellectual maturation of children. Teachers should be aware that cognitive growth and learning are dependent on maturation, physical experience, social transmission, equilibration and self-regulation. A match between complexity of subject matter and the child’s level of conceptual development is to be ensured for ideal learning. Disequilibrium must be maintained before the commencement of the class. Regulate the difficulty level and order of presentation of material or structure and sequencing are necessary for presenting the subject matter. Teachers should keep a hierarchical or orderly presentation of experiences for concept learning. Teachers keep in mind that mental age is more valid than chronological age. Teachers should provide
learning experiences based on concrete objects and situations. Teachers should give emphasis to experimental and practical aspects. Provide direct experiences at each and every step during teaching. Care should be taken to develop lower level schemata in order to build higher level schemata. Active participation of each child is ensured during teaching. Ensure adequate array of physical experiences for enriching learning (Jha, 2009; Jha, 2006; Mc Vee, Dunsmore & Gavelek, 2005; Cohen, Manion & Morrison, 2004; Woolfolk, 2004; Rodriguez & Berryman, 2002; Windschitl, 2002; Hruby, 2001; Prater, 2001; James, 1999; Marcus, 1998; Oxford, 1997; Confrey, 1991).

2.23.5. Classroom Transaction

The learning process allows the student to experiment and participate in hands-on-activities. Teachers encourage student to reflect and to construct their own meaning (Sood, 2004). Students control their learning process and they proceed by reflecting on their experiences. The teachers help to create situations where students feel safe. The teacher should also create activities that lead the students to reflect on his/her prior knowledge and experiences. The classroom should provide situations for problem solving and inquiry-based learning activities with which students formulate and test ideas, draw conclusions and inferences individually (Reddy & Shyamala, 2005). Teachers should help students to discover relationships among concepts and ideas. The transaction process should provide opportunities for students to share opinions, perspectives, and beliefs. Teachers should ask students to describe how they are thinking about information and to explain the logic they are using when drawing conclusions.
Teachers should arrange the classroom tasks and assignments according to the developmental level of children (Rajan, 2013; Ormrod, 1998).

Three principles of classroom transaction derived from Piaget’s theory are: (1) Emphasis on discovery learning, (2) Sensitivity to children’s readiness to learn and (3) Acceptance of individual differences (Berk, 1993).

**Emphasis on discovery learning**

In a Piagetian classroom, children are encouraged to discover for themselves through spontaneous interaction with the environment. The classroom should be equipped with a rich variety of materials and play areas designed to promote exploration and discovery-art, puzzles, table games, dress-up clothing, building blocks, reading corner, wood working, and more. The children can choose freely from among these activities. Provide opportunities for students to experiment with new objects and to experience new events.

**Sensitivity to children’s readiness to learn**

A Piagetian classroom does not try to speed up development. Instead, appropriate learning experiences build on children’s current level of thinking. The teacher does not impose new skills before children indicate that they are interested and ready. So make sure that students have prior knowledge and experiences to which they can relate new material.

**Acceptance of individual differences**

Piaget’s theory assumes that all children go through the same sequence of development, but they do so at different rates. So teacher makes special effort to plan...
activities for individual children. Since individual efforts are expected the teacher evaluates the educational progress by comparing each child to his or her own previous course of development.

2.24. Social Constructivism

The conceptual framework of social constructivism draws from the works of the Russian psychologist Lev Semanovich Vygotsky (1896-1934) and the Russian literary critic and philosopher Mikhailovich Mikhail Bakhtin (1895-1975) (Savasci & Berlin, 2012; Edwards, 2007; Rodriguez & Berryman, 2002; Pon, 2001). Vygotsky believed that social interaction, cultural tools, and activity shape individual development and learning. So the name Vygotsky’s socio-cultural perspective. It is also referred as ‘Second wave constructivism’ (Woolfolk, 2004).

2.24.1. The Theory of Knowledge

The social constructivists suggest that knowledge is socially constructed and mediated by socio-cultural, historical, and institutional contexts. Vygotsky views knowledge as primarily a cultural product and shaped by micro and macro cultural influences and evolves through increasing participation within different communities of practice. The context-dependent knowledge, acquired during the course of growing up enables the individual to cope in the world of which s/he is a part.

Social constructivists argue that language, more than the individual mental process, is a representative locus for knowledge (re) construction. The cognitive system
is a result of interaction in social groups and cannot be separated from social life (Edwards, 2007; Woolfolk, 2004; Benedict, 2002; Rodriguez & Berryman, 2002; Windschitl, 2002; Oxford, 1997; Confrey, 1991).

2.24.2. The Learning Process

Vygotsky, Dewey and other researchers have argued that learning begins from a social context (Jefferies, Carsten-Stahl & McRobb, 2007). For social constructivists learning is a social, collaborative, interactional activity, in which shared problem-solving experiences with more experienced members of the society (parents, teachers, peers or siblings) and enhance learning (Rajan, 2013; Jadallah et al., 2011; Jha, 2009; Sindhya, 2008; Jefferies, Carsten-Stahl & McRobb, 2007; Gagnon & Collay, 2006; Jha, 2006; Cohen, Manion & Morrison, 2004; Geetha, 2004; Sood, 2004; Dash, 2002; Hruby, 2001; Pon, 2001; James, 1999; Nicase & Barnes, 1996; Confrey, 1991). Vygotsky’s meaningful “whole” activities include conducting experiments, scientific inquiries, solving authentic problems, creating and interpreting library texts, etc. Vygotsky viewed thinking as a characteristic not only of the child but of “child-in-social activities” (Windschitl, 2002).

The perceptions of the experience of people vary according to the social, cultural and physical environments and the symbol systems that have been learned prior to the events. By interacting with others in relation to the events, learners incorporate different perspectives into their understanding of what they have already experienced (Prater, 2001). In this manner the constructed meanings are gradually revised through socio-
cultural activity. Social constructivists considered “group” as “learning collectives” or “learning units.” The knowledge is a possession or property of a group, not only of the individual participant in the group (Sawyer, 2004).

Vygotsky believed that social interaction guides student’s thinking and concept formation where language plays a central role in cognition. Language is a method for expression of ideas, asking questions and creating categories for concept for thinking. Discourse and dialogue become essential in learning process. It enables students to view knowledge and information for multiple perspectives (Nicase & Barnes, 1996). The three important terms used to describe the views of Vygotsky are: (1) the Zone of Proximal Development, (2) Scaffolding and (3) Private Speech (Kail, 1998).

The Zone of Proximal Development (ZPD)

Vygotsky refers to what children can do independently, during learning; on their own is the “level of actual development.” What children can do with the help of others guidance or collaboration with others is referred to as the “level of potential development” (Jadallah et al., 2011; Mody, 2011; Jha, 2009; Jha, 2006). The difference between what a person can do with assistance and what s/he can do alone defines the Zone of Proximal Development (ZPD). That is the Zone refers to the difference between the level of performance a child can achieve when working independently and the higher level of performance that is possible when working under the guidance of more skilled adults or peers (Jadallah et al., 2011; Harlen & Qualter, 2006; James, 1999; Berk, 1993). The concept of ZPD indicates that learning is directly related to social development.
Within the framework of the ZPD, two concepts will be tied in, viz., Scaffolding and Approximation.

**Scaffolding**

The term ‘scaffolding’ comes from the works of Wood, Bruner and Ross (1976) as the process of transition from teacher assistance to independence (Jadallah et al., 2011; Geetha, 2004; Kail, 1998). It describes the type of assistance offered by peers, teachers or other members. In other words it is the process that enables a child or novice to solve a problem, carryout a task, or achieve a goal which would be beyond his/her unassisted efforts (Jadallah et al., 2011). It is actually a bridge used to build upon what students already know to arrive at something they do not know (Lipscomb, Swanson & West, 2004). The acquired specific cultural tools, handed over to children by more experienced members of the society, facilitated the acquisition of higher mental functions (Bunch, 2009). So scaffolding is a teaching style that matches the amount of assistance learners need (Jadallah et al., 2011; Cakir, 2008; Harlen, 2006; Harlen & Qualter, 2006; Geetha, 2004; Kail, 1998).

The original use of the metaphor scaffolding had no explicit reference to Vygotsky. The implicit link between Vygotsky’s Zone of Proximal Development and scaffolding was first made explicit by Cazden (1979). Ever since, scaffolding metaphor has been used to describe how educators can best assist learners within the Zone of Proximal Development to nudge them forward until the learners can independently apply a newly acquired strategy (Jadallah et al., 2011). Scaffolding promotes effective knowledge construction in the classroom. Scaffolding helps the children in active
construction of knowledge, relating information to prior knowledge, organisation and integration of information. Scaffolding sometime takes the form of a cognitive apprenticeship. Cognitive apprenticeship involves two people working together to accomplish a challenging task or a difficult problem (Ormrod, 1998). An idea related to scaffolding and mastery of a task within the Zone of Proximal Development is approximation. Roggoff (1995) defines it as a process by which individuals transform their understanding of and responsibility for activities through their own participation (cited in Jadallah et al., 2011).

**Silent Speech or Private Speech**

Children are more likely to talk to themselves as they attempt to solve problems or achieve important goals. Vygotsky call this system of internal speech as “conversation in one’s belly” or “conversation with one’s heart.” This is the result of suppressed, undisclosed movement of the motor mechanism of an individual. This non-social speech is the basis of correction of every thought process. It is the result of complex involvement of respiratory, muscular and vocal reactions (Vygotsky, 1999).

The non-social speech increased dramatically whenever these young problem solvers encountered obstacles as they pursued their objectives. This non-social speech is communicative. This ‘private speech’ or ‘speech for self’ helps young children to plan strategies and regulate their behaviour so that they are more likely to accomplish their goals. Thus, language plays a crucial role in cognitive development by making children more organized and efficient problem solvers. Vygotsky also claimed that private speech becomes more abbreviated with age, progressing from the whole phrases that 4-year-olds
produce, single words, to simple lip movements that are more common among 7-9-year-olds. According to him the private speech never completely disappears; instead, it simply goes underground, becoming silent or inner speech the covert verbal thought that people use to organise and regulate their everyday activities (Shaffer, 1996).

2.24.3. The Learner

Vygotsky’s focus is on the group rather than the individual. Vygotsky places the role of social interactions at the forefront of his theories. For him, activity is inherently social, and it is through the engagement in activity, in the company of parents, peers, teachers and others, that intellectual development transpires. He gives primary focus to the activity of appropriation by which a child learns to internalise the values and organising knowledge structures of a culture. Constructivist learner involves in interactions, collaborations and cooperative activities between other members of the society (Jadallah et al., 2011; Khader, 2005; Sawyer, 2004; Confrey, 1991). The learners are said to benefit from both explaining to others and having material explained to them. It helps children to acquire the ways of thinking and behaving that make up a community’s culture. It also contributes to master culturally meaningful activities. The learners are given opportunity to publicly display their constructions of knowledge before their peers. Cultural and language factors significantly influence the learning process of the learner. The personal factors such as interest, comprehension and confidence of children are considered important in the process of learning (Remedios, Clarke & Hawthorne, 2008; Berk, 1993).
2.24.4. The Teacher

Teachers in Vygotsky’s classroom would favour guided participations in which they structure the learning activity, provide helpful hints or instructions that are carefully tailored to the child’s current abilities. They then monitor the learner’s progress, gradually turning over more of the mental activity to their pupils. Teachers may also arrange cooperative learning exercises in which students are encouraged to assist each other; the idea here is that the less competent members of the team are likely to benefit from the instruction they receive from their more skillful peers. The teacher is a project manager, tutor or coach, test creator, scaffolder, mentor, advisor, coordinator, problem task presenter, facilitator, resource person and midwife. Teacher as a member of the team provides technical assistance and creative consultation. Teacher is also a student as the children discover new procedures and instruct the teacher in their use. As a reflective practitioner teacher has to create information rich environments where students can think, explore, and construct meaning collaboratively. Teacher should provide multiple sources of information using cooperative learning strategies that emphasise collaboration. A proficiency in creating dynamic social environments that foster interplay among students, materials and ideas is expected from the teacher (Jadallah et al., 2011; Sindhya, 2008; Jefferies, Carsten-Stahl & Mc Robb, 2007; Edwards, 2007; Jha, 2006; Cohen, Manion & Morrison, 2004; Geetha, 2004; Sawyer, 2004; Sood, 2004; Woolfolk, 2004; Benedict, 2002; Dash, 2002; Rodriguez & Berryman, 2002; Windschitl, 2002; James, 1999; Oxford, 1997; Nicase & Barnes, 1996).
2.24.5. Classroom Transaction

The literature substantiates the peculiarities of social constructivist classroom as collaborative, cooperative, context-dependent, case-based or problem-based considering the interest, curiosity and inquisitiveness of students. Learning environment is based on primary sources and raw data. The activities are challenging and realistic in nature. The real-world experiences of the children are considered or a realistic approach is followed. Team projects and group works are arranged in the social context in order to ensure proper scaffolding. Students explore ideas themselves in focused play and meaningful dialogue between students, peers, and teacher. Multiple sources of learning environments are encouraged to facilitate higher order thinking. There are provisions for individual negotiation and questioning others point of view. A democratic social environment is ensured for considering others point of view and multiple ways for solving problems (Rajan, 2013; Jadallah et al., 2011; Sindhya, 2008; Edwards, 2007; Jefferies, Carsten-Stahl & Mc Robb, 2007; Jha, 2006; Kim, 2005; Cohen, Manion & Morrison, 2004; Geetha, 2004; Sawyer, 2004; Sood, 2004; Woolfolk, 2004; Benedict, 2002; Dash, 2002; Rodriguez & Berryman, 2002; Windschitl, 2002; Confrey, 2001; Hruby, 2001; Pon, 2001; Prater, 2001; James, 1999; Oxford, 1997; Nicase & Barnes, 1996).

2.30. Related Studies

A brief analysis of relevant studies in a systematic manner will be helpful for developing a critical understanding about the recent practises and problems encountered in the constructivist classrooms. The constructivist paradigm came to classroom practice
only in the recent decades. So the empirical studies available are very few in number. However, Thirty four studies were identified as relevant to the present investigation. The studies are from different areas such as Information Systems Education, use of Technology in the constructivist classrooms, Teacher Education, General structure of constructivism, Mathematics Education and Science Education. The studies in disciplines other than science are not reviewed here in detail.

2.30.1. Studies in the discipline of Information Systems Education

Bunch (2009) conducted a comparative study of two scaffolding methods to reduce cognitive load in the teaching of introductory data base concepts. The study revealed that problem-centred constructivist instruction in the classroom provides an effective approach to teaching. Munoz Rozario and Widmeyer (2009) conducted a study on an exploratory review of design principles in constructivist learning environments based on games and reported that all games were highly engaging to players, provided a safe environment for in-game risks, and allowed students to practice some skills. Wu and Bieber (2008) conducted a study on engaging students with constructivist participatory examinations in Asynchronous Learning Networks and found that a majority of students preferred a constructivist, cooperative and engaging learning experience and students believed that the approach increased their learning.
2.30.2. Studies related with use of Technology

Larkin-Hein, Iruine, Prejean, and Lesiak (2001) conducted a study on constructing knowledge networks through hands-on experiences in the constructivist middle school classrooms. The result shows that constructivist theory can be successfully implemented when intertwined with current internet technologies and various content areas. Rakes, Flowers, Casey and Santana (1999) analysed instructional technology use and constructivist behaviours of K-12 teachers. The study examined the relationships between teacher perceptions of constructivist behaviours and use of technology in their classrooms. Results indicate that integrated technology use in the classroom and strong technology skills encourage teachers to use constructivist practices.

2.30.3. Studies in the arena of Teacher Education

Paucharearn and Fisher (2008) studied in-service teacher-training process for improving constructivist learning environments in Thai small school classrooms. The main objective of the study was to find out changes in teachers’ competencies to improve their classroom environments by creating networking process using a constructivist perspective. The findings confirmed that teachers are able to make use of learners’ responses to the constructivist learning environments to improve their own classroom learning environments. Teachers’ attitude towards a networking process activities and self-efficacy were changed positively after using network activities. Teachers who receive support and training can consider students’ views about their classrooms and improve their classroom environments. Consequently, teachers can develop and apply
their own plans to induce classroom environment changes based on their students’ actual and preferred constructivist learning results.

2.30.4. Studies related to General Structure of Constructivism

Edwards (2007) conducted a study to examine the appreciation of socio-cultural theory by a group of Australian early childhood educators participating in a professional development programme by Developmental Work Research (DWR). DWR suggests that changes adopted within an activity system by teachers are more readily articulated to practice than those externally imposed or exhorted upon practitioners.

Cunningham (2006) conducted a case study on the seven principles of constructivist teaching, that explored the qualities that identify a constructivist teacher and also examined what a constructivist curriculum looks like in a primary classroom. The study was conducted on a master teacher in an urban school. Tools and techniques used for the study were observation, interview, lesson plans and test scores. The triangulation of data revealed that the teacher easily met the seven basic principles of constructivist teaching.

Johnson (2006) conducted an action research on a constructivist approach to evaluate eighth grade students. The study was presented as a genuine “voice from the field” about constructivist approaches to teaching of English Language Arts. The strategy developed were open selection of topics, creative writing assignments, observation, peer conferencing, use of critical friends review as a formative evaluation,
support and constructivist design conference and feedback. The result shows that most of
the students liked the project better and increased their proficiency in English.

Zan and Hildebrandt (2005) studied cooperative and competitive games in
constructivist classrooms. The study was to establish the validity of constructivist
hypotheses such as mutual respect between teachers and children and interpersonal
understanding between children themselves in constructivist classrooms. The results
suggest that both cooperative and competitive games have value in constructivist
classrooms.

Cook, Smagorinsky, Fry, Konopak and Moore (2002) conducted a case study of
an elementary school teacher on problems in developing constructivist approach to
teaching. The researcher analysed her constructivist conceptualisation of teaching as she
moved from the formal environment of university programme of student-teaching to the
practical environment of schools. Data were collected through pre-teaching interviews,
classroom observations, pre-and post observation interviews, group concept map
activities, interviews with supervisors and administrators, and artifacts from schools and
teaching. The analysis showed that the teacher, rather than developing and sustaining a
concept of constructivist teaching, a less unified understanding and application of the
abstraction.

Sheehy (2002) studied structure, discourse, and subjectivity of constructivism in a
middle school classroom. The purpose of the study was to reveal constructivism within a
classroom politically. The researcher analysed variations of constructivism in one 8-
week project, called the building Project. A seventh grade teacher taught in science and
social studies in an urban middle school as per the project. The result shows that the students would learn better in constructivist learning situations.

Rodriguez and Berryman (2002) conducted a study on using socio-transformative constructivism to teach for understanding in diverse classrooms. The study was focused to implement socio-transformative constructivism in the actual classroom after the conception of conceptual framework. The result of the study acts as a bridge that connects new knowledge with transformative action.

Hammett and Collins (2002) studied knowledge construction and dissemination in graduate education. The focus of the study was to find out whether the seminar course which incorporated a social constructivist approach can enable graduate students to construct and disseminate knowledge. The result revealed that it did help them and students become directly involved in knowledge construction and dissemination.

Hay and Barab (2001) conducted a study to compare and contrast two learning environments, one based on constructivist learning theory (learner-centred focus) and the other based on legitimate peripheral participation or apprenticeship learning (community-centred focus). The study explored the overall similarities and differences between the two environments, focusing specifically on issues of authenticity, ownership, power, and task structure. The result shows that both environments share authenticity of practices and goals, ownership of the environment by the learners as both grouped frequently under the umbrella term of constructivism.

Cobb (1999) conducted a study to find out how applications of constructivist learning environment contribute in developing the learner as a scientist. The study was
conducted to establish conditions in which the prediction (constructivist learning theory predicts that knowledge encoded from data by learners themselves will be more flexible, transferable and useful) can be operationalised and tested. The adaptation of constructivist principles to instructional design in second language vocabulary acquisition indicated that children can transfer their knowledge to novel contexts.

Chan Carrol, Burtis, Scardamalia and Bereiter (1992) studied constructive activity in learning from text. The study examined children’s integration of new information when they learn from text. Correlational findings showed that age, prior knowledge, and constructive activity were all related to learning outcome.

The studies related to Peer Assisted Learning Strategies (Fuchs, Fuchs, Mathes & Simmons, 1997), Knowledge Construction (King, 1994; Nuthall & Alton-Lee, 1993), and Cooperative, Competitive, and Individualised learning (Owens & Barnes, 1982) are not described in this section because these studies dealt with only a few aspects of constructivism.

2.30.5. Studies in the discipline of Mathematics Education

The literature shows that constructivist perspectives on learning have been most prevalent in mathematics education. Three empirical studies that are relevant are reviewed here.

Kim (2005) studied the effects of a constructivist approach on student academic achievement, self-concept, and learning strategies and found that constructivist teaching is more effective than traditional teaching in terms of academic achievement.
Boaler (1998) conducted a study to establish the effectiveness of constructivist learning environment on open and closed mathematics. Sample included students of grade nine to twelve mathematics classes from two different schools. One school was grounded in constructivism and the other in traditional pedagogy. The study revealed that the traditional textbook approach that emphasises computation, rules and procedure is disadvantageous to students because it encourages learning that is inflexible, school-bound and of limited use.

Anthony (1996) conducted a case study on active learning behaviours of two students in a constructivist framework. This study examined sixth form mathematics students’ use and awareness of learning strategies in their authentic learning environment. The study revealed that individual interpretations of the learning activities and use of learning strategies are unique to each student.

2.30.6. Studies in the discipline of Science

Savasci and Berlin (2012) conducted a multiple cross case study to gain a deeper understanding of science teacher beliefs and classroom practice related to constructivism. The study focused on what are the beliefs of science teachers, how do they implement these beliefs in science classrooms, are these beliefs consistent with their classroom practice, and what are the factors influencing implementation of constructivism in science classrooms. Four science teachers working in different school settings were purposively selected based on their willingness to participation in the study. Two of them were working in urban public school and other two were working in urban private school.
The data were collected using two semi-structured interviews, a demographic questionnaire, a Classroom Learning Environment Survey (CLES), classroom observations, and classroom documents (lesson plans, hand outs/worksheets, and assignments). Based on a comparison of the five components of personal relevance, scientific uncertainty, critical voice, shared control, and shared negotiation on the CLES, reveals that personal relevance and student negotiation were the most frequently preferred components of constructivism across all four teachers. All participants believed that school science should be relevant to student lives outside of school. They also believed that students could learn from each other by discussing ideas and concepts. The CLES revealed that the teachers did perceive that they implemented all of their beliefs into classroom practice. All four teachers upheld their autonomy to decide what to teach and how to teach.

Analysis regarding implementation of beliefs confirmed that all four teachers, included teacher-centred activities primarily lectures, questioning, discussions, worksheets, and video/demonstrations, while student-centred activities primarily included student projects, presentation, and hands-on activities. Three teachers spent more time in teacher-centred activities than student-centred activities. Only one teacher allocated more class time to student-centred activities. In summary, teacher expressed beliefs were not consistent with their classroom practice. However, the investigator ensured equality with respect to teaching experience and qualification of participating teachers, age is not controlled properly as one of them 60-year-old and other three with a range of age 32-38.
Milner, Templin, and Czerniak (2011) studied influence of constructivist classroom contextual factors in a life science laboratory and a traditional science classroom on elementary students’ motivation and learning strategy use. The method adapted for the study was causal-comparative mixed design. The study attempt to answer in what ways and to what extent - - do regular classrooms differ from the Xtown Environmental Life Laboratory (XELL) in constructivist classroom contextual factors over time, do Xtown 5th grade science students’ motivation differ when studying science in their regular classroom compared to science in the XELL over time, and do Xtown 5th grade students’ learning strategy use differ when studying science in their regular classroom compared to when studying science in the XELL over time.

Four fifth-grade teachers whose classes use the XELL in their science curriculum were the participants of this study. The XELL was examined as a learning environment that can enable classroom contextual factors to support constructivist teaching and learning practises. The XELL is comprised of an arboretum, terrarium and aquarium furnished with various habitats, biomes and ecosystems (including but not limited to a 1500-gallon fresh water stream/pond, butterfly house, 1500-gallon saltwater ecosystem, bird aviary, herpetology area, invertebrate zoo, and vegetable/flower gardens) that offer areas to study throughout the school year as well as from year to year. Four fifth-grade classes that use the XELL in their science curriculum were the participants of this study. So four teachers and 67 students were included in the final analysis.

The instruments and data sources were Constructivist Teaching Inventory observation form (CTI), Teacher Unit Topics and Lesson plans, and Motivated Strategies
for Learning Questionnaire self report survey (MSLQ). Classroom observations (regular classroom and XELL) were made at the beginning of the semester, midway of the semester, and at the end of the semester. All observations were video-taped.

The results show that the constructivist teaching and learning practices were found to occur more often in the XELL, than in the regular classroom regardless of teacher. Student motivation and learning strategy use were found higher in the XELL than in the regular classroom. Overall, students enjoy working in the XELL. Every student expressed their understanding of the importance of the XELL experience on their education. This study suggests that life science laboratories in elementary schools support and promote student motivation and learning strategy use.

Brand and Moore (2011) studied teachers’ application of inquiry-based strategies using a constructivist socio cultural professional development model. Research was conducted for investigating the impact of the professional development activities on teachers’ practises, documenting the philosophical as well as instructional changes and how these changes shaped the learning environment.

Thirty K-5 teachers from a rural elementary school participated in the professional developmental activities. The number of teachers was basically the same across the grade levels. Teachers, like students, learn through meaningful engagements such as inquiry-based workshop activities, grade-level study groups, team planning, and implementation of instruction and whole and grade-level group discussions over a sustained period of time. Interviews and Semantic Maps (diagrammatically represents the ideas of teachers progressively developed as a result of learning programmes like
concept maps) were used to track changes in the teachers’ conceptions of constructivist inquiry based strategies.

During the three year Project interviews were conducted once in the middle of every year. The Semantic Maps were developed at the beginning and ending of the two-week summer sessions and later revised at the middle and at the end of the school year. Semantic Maps are useful in identifying changes in an individuals’ knowledge occurring as a result of their participation in a set of learning experiences. It illustrates teachers’ adaptation of new understandings to their previous ideas. So it helped the researchers to track the progression of their understanding about science teaching from their participation in the initial professional development activities. A conceptual comparison method was used to guide the analysis of work. The reviewing process occurred as one segment in whole-day group planning meetings in which the participants and researchers reviewed and discussed the transcripts to avoid misinterpretations.

The results show that constructivist professional development model encouraged teachers’ critical analysis of their instructional practices and modifications. The programme influenced changes in teaching philosophies and beliefs of teachers, teachers’ perception, feeling of efficacy toward science, feeling of competencies in teaching in science and their content according to their prior knowledge and experiences. They also reported that they gained insight into the composition of inquiry-based strategies, influenced students’ performances in other areas of learning, students’ interests and motivation improved their attitude toward learning and researching new ideas. Out of thirty teachers, two teachers were found at transformational level.
Khourey-Bowers and Fenk (2009) studied the influence of constructivist professional development on chemistry content knowledge and scientific model development. The purpose of the study was to explore the relationship between in-service teachers’ participation in chemistry-specific Constructivist professional Development (PD) and enhancement of their chemistry Content Knowledge (CK) and Pedagogical Content Knowledge (PCK) and Personal Science Teaching Self-Efficacy (PSTE).

The study used a pre-experimental, one group pretest/posttest design. The participants, a convenience sample of in-service teachers (69), voluntarily applied to participate in the grant-funded PD. Teachers were accepted based on their teaching assignment (chemistry topics), grade band (grades 4-9), and timeliness in completing the application. The study was carried out over two consecutive years. The research design used a dominant less dominant methodology in which quantitative (dominant) and qualitative (less dominant) data sources were used. The data instruments used were Content Knowledge Pretest and Post test instrument and Science Teaching Efficacy Belief Instrument (STEBI).

The results show that content knowledge (CK) of elementary teachers was enhanced, but CK was not affected for teachers of middle/secondary grades. The use or understanding of multiple levels of scientific models was enhanced in the total sample and in the elementary sub-group, but not in the middle/secondary sub-group. Both sub-groups and the total sample made significant gains in PSTE and demonstrated enhanced PCK through selected lesson narratives.
Yager and Akcay (2008) compared student learning outcomes in middle school science classes with Science, Technology, and Society (STS) approach and a typical textbook dominated approach. The purpose of the study was to determine whether science, Technology, and Society (STS) format with constructivist learning increases student mastery, general science achievement, use of concepts in new situations, and attitudes toward science in middle school classrooms.

The study involved two teachers and fifty-two students in grades six through eight. Two batches of middle school science students were taught by two teachers where one used an STS approach and the other retained a typical use of the textbook as a class organiser. The tools used for the study were: (1) Pre-and-post tests, (2) Inquiries to measure application of concepts to new situations, development of positive attitudes and exhibition of creative skills, (3) Attitude scale developed from items of the Third Assessment of Science by the National Assessment of Educational Programmes (NAEP, 1977), and (4) Surveys. The exposure was given to the participants for 3 to 4 weeks. The ‘t’ test was used to find out the significant difference between the groups. Major findings indicated that students taught using STS approach showed better performance in the mastery of basic concepts, general concepts, application of science concepts, positive attitudes about science, creativity skills, and use science at home and community.

However, teacher is an important variable which was not controlled in this study. In other words both teachers differ in their teaching experiences. The one had twenty one years of teaching experience and the other with only twelve.
Dogru and Kalender (2007) conducted a study on applying the topic “cell” through constructivist approach during science lessons and the teacher’s view. The objective of the study was to apply topic of cell in the primary school science lessons according to the constructivist approach and obtaining teacher’s point of views. The sample for the study was 53 science teachers from 23 schools and 52 students (24 control group and 28 experimental) from one school. The poll (The poll is an observation schedule having a list of questions that can be directly read and answered) and application method were used in this study. The poll has been applied in 23 primary schools for 53 teachers for a period of one month. The application was conducted in the experimental group of 28 children and control group of 24 children. After the poll is applied and collected, SPSS programme was used for analysis. ‘t’ test was used for analysis and interpretation. The result shows that constructivist teaching approach and traditional teaching has an important and significant difference in the sustainability of the learned lessons, although the very approach in this study is suspect to be qualified as a constructivist approach.

Kimble, Yager and Yager (2006) studied success of a professional development model in assisting teachers to change their teaching to match the National Science Education Standards (NSES). This study was an examination of the teaching practises of eight middle school teachers. Specifically, constructivist teaching practises of these eight teachers were studied over a six year span, i.e., 1994-2000. All the eight teachers taught in middle schools. Tools and techniques used were direct classroom observation, reviews of videotapes (recordings of at least three consecutive days of teaching), student
evaluations, written teacher responses to specific questions, and teacher responses to questionnaires. The data were collected beginning in 1994 and ending in 2000. Changes in constructivist teaching practices were measured using the four subscales of the Expert Science Teaching Educational Evaluation Model (ESTEEM) rubric. The ESTEEM is an instrument designed for observing the extent and the nature of constructivist practices in use by the teacher observed. Analysis of variance (ANOVA) was used to estimate the significant differences.

The findings indicate that constructivist teaching practices can be successfully implemented. Further, all aspects of learning of students in constructivist classrooms increased, especially related to process skills; thinking and designing skills; achievement scores; ability to apply concepts and skills to new situations; and the development of more positive attitudes concerning science, science study, and science careers. Eight teachers continued to grow in terms of constructivist strategies beyond the funding period and in ways illustrating that the kind of teaching advocated by the National Science Education Standards (NSES).

Shin, Yager, Seok Oh and Lee (2003) studied changes in science classrooms after experiencing an International Professional Staff Development Programme. The study was to find out the changes in teaching practices of Korean science teachers who participated in Lowa Chautauqua Summer Workshop and the resultant improvement of learning of their students.

The procedure of the study included: 1) Three week summer workshop, 2) Use of five day modules in classrooms (what the teachers learned during the summer workshop
were applied in actual classroom contexts), and 3) Feedback and follow-up support for the teachers to their modules and use them on a continuing basis. The samples of the study were 10 Korean teachers and their 459 students. The teachers taught grade levels that ranged from the 8th through 11th. The teaching practises of teachers were observed through videotapes (three video tapes: pre-worked lesson, post-worked lesson, and follow up lesson). All video tapes were analysed and scored using the Expert Science Teaching Educational Evaluation Model (ESTEEM). The scores were statistically analysed using repeated measures of ANOVA. The mastery of concepts was determined using written tests prepared by three participant teachers. To measure the growth in student creativity, the Assessment of Student Creativity (ASC) instrument was employed. Semi-structured interviews were conducted to gain information about teacher perceptions concerning their use of constructivist approaches in their classrooms.

The result shows that constructivist approaches were significantly contributed in concept mastery, and creative talents in students. Most of the teachers were in favour of constructivist ideas, even though they felt that it was difficult to use constructivist approaches in their classrooms. Four of the teachers stated that they would like to continue using these approaches in the future. Most teachers reported that their students become more interested in constructivist lessons over time. They also revealed that though constructivist lessons motivating students to be involved in classroom activity one limitation observed was its inability to cover all information. The seven teachers improved their science teaching after the programme and the follow-up trials which advocated using constructivist teaching modules.
The teachers became facilitators of learning; they encouraged students to initiate examples and ask questions; they used novelty, discrepancies, and curiosity to motivate student to learn; they tried not to depend on textbooks to dictate lessons; also, they focused more on activities that pertained to student understanding of concepts as they employed various teaching strategies, including higher order thinking skills, integrating content and process, and making connections among major concepts.

One of the teachers involved in this study reported that his students did not favour constructivist approaches because they did not like being asked frequently to think and to find out more about a topic they were learning. The analysis of the study aroused a question in the mind of the researcher that how the peer teachers acting as students in the summer workshop help the teachers to face students in the real classroom?

Wing-Mui So (2002) conducted a study on constructivist teaching in primary science. The study was aimed to find evidence of constructivist teaching amongst teachers in primary science lessons and to identify any changes in the extent of constructivist teaching when teachers advanced from pre-service to novice teaching. The participants were pre-service teachers of the Certificate in Primary Education (Two-year Full-Time) Course. A class of 25 student teachers taking the Science Curriculum Studies Module was invited to be the subjects of the present study, and was followed through their two years of study and in their first year of beginning teaching.

In order to make an overview of the teachers’ changes in their practice of teaching from pre-service teacher education to beginning teaching, a longitudinal study was conducted with teachers for three academic years. The first two stages were the pre-
professional phases during initial teacher education, and the final stage was the beginning teaching year. Student teachers were observed once every year throughout the three years of the study to capture the extent of their constructivist teaching. Data was recorded in different ways that included the researcher’s observational field notes, video and tape recordings of teacher’s talks with the class and discussions among pupils. The student teachers’ performances as judged in six areas of constructivist teaching were: (1) Using learners’ existing knowledge to guide teaching, (2) Guiding learners to generate explanations and alternative conceptions, (3) Devising incisive questions, (4) Choosing materials and activities for learners to test ideas, (5) Providing a classroom atmosphere conducive to discussion, and (6) Providing opportunities for learners to utilize ideas. The findings showed that there was a gradual shift of constructivist teaching among teachers throughout the longitudinal study.

Chang (2001) studied the constructivist approach of teaching and portfolio assessment on science teaching to find out the impact of the constructivist approach of teaching and portfolio assessment in elementary science learning. It was a Quasi-Experimental design and involved four regular classes, 186 fourth graders and two science teachers in the same elementary school in Taiwan. The experimental and control groups were assigned randomly. The two teachers were also assigned randomly for each group in which one group was taught through conventional teacher-centred approach and the other one was through constructivist approach. The tools used were pre-tests, post-tests, and retention test. The analysis of covariance of post-tests showed that the constructivist approach had a beneficial effect. Even though the study was focused on
portfolio assessment, no reflection was found about the aspects of portfolio assessment and how these factors were considered in the study.

Yager (1995) conducted a study on Science/Technology/Society (STS) a reform arising from constructivist learning theory and research. The purpose of the study was to evaluate effectiveness of a school programme Viz., Lowa-Scope, Sequence & Coordination programme (Lowa-SS & C). The Lowa-SS & C is a programme intended to produce constructivist teachers to implement the reform. The effectiveness of the programme was evaluated by examining improvements in student learning in six learning domains: concept, process, application, creativity, attitude, and world view. Most of the teachers in this study taught only Lowa-Scope, Sequence & Coordination (SS & C) sections; however, 20 teachers agreed to maintain one or more sessions where the textbook was used extensively. This provided us with both experimental and traditional classrooms and students for the study. All of these teachers were asked to respond to determine changes in teacher confidence, use of certain teaching procedures, and changes in teacher perceptions of various student attributes. Additionally teacher success was measured by action research projects designed to test their ideas about their own teaching. A total of 105 teachers were invited to serve as control group. Forty-eight agreed to participate in the study. Pre and post-tests were administered to all students of 133 SS & C teachers during 1990-1993. In total these teachers were responsible for the learning of 1976 sixth grade students, 1650 seventh grade students, and 1644 eighth grade students. Over the duration of the study, non-SS & C students included 429 sixth grade students, 440 seventh grade students, 451 eighth grade students. Tools used for the
study were multiple choice tests to measure the concept domain, the process domain (13 skills identified by the AAAS), and application domain. The creativity domain is measured by students’ responses to directions. The attitude domain and world view domain were measured through 5-point Likert scale.

The evaluation reveals that the programme successfully responds to calls for reform and restructuring of middle school programmes. And also issue-oriented instruction is found to be superior in terms of stimulating changes in teacher confidence to teach, using desirable teaching practises and utilising students in ways that characterise constructivist teaching. It also results in significantly improved student learning in terms of creativity, understanding process skills and concepts, attitude domain, world view, and the development of positive attitude for school study, teachers, and related careers.

Burton and Brueckner (1955) reviewed studies in the arena of curriculum evaluation. According to them most of the studies were conducted based on analysis of products, promotional policy, opinion polls about drop outs, factors maintaining status (status quo), general activities of teachers and use mode of resources within the setting for learning such as flexibility, periods, supplementary materials, pupil freedom, and democratic environment, professional activities of teachers, evaluating the documents, and use of resources for maintaining school-community relationship. Apple and Beyer (1983) mentioned that curriculum evaluation is usually based on achievement test results.

The review of related studies reveals that there are very few studies on constructivist paradigm. Almost all studies reviewed are related to effectiveness of constructivist mode of teaching on learning outcomes, impact of inquiry based
constructivist strategies on professional development of teachers, success of professional development models on teaching, changes in science classrooms after experiencing international staff development programmes, effectiveness of constructivist strategies on teaching and portfolio development, and effectiveness of constructivist STS approach. No studies were available related to curriculum evaluation focusing on classroom practises and problems faced by students and teachers. And the review reflects that most of the researches have not looked at the classroom transactions that reflect the curriculum change. This necessitates research in the area of curriculum evaluation based on constructivist perspective and practice.
CHAPTER III

METHODOLOGY
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3.10. Overview
3.20. Statement of the Problem
3.30. Objectives of the Study
3.40. Hypotheses of the Study
3.50. Research Design and Procedure
3.51. Population of the Study
3.5.2. Sampling Procedure
3.5.3. Tools used for the Study
3.5.4. Validity and Reliability of Tools
3.5.5. Collection of Data
3.5.6. Statistical Treatment of Data